hildebrand

Smart Meter System Based Internet of Things Applications

SMIOTS

Final Report – Publishable Version

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Table of Contents

Glossary

Acronym	Definition
BEAMA	British Electrotechnical and Allied Manufacturers' Association
CAD	Consumer Access Device
CBA	Cost Benefit Analysis
CEM	Customer Energy Management
CHF	Communications Hub Function
CPA	Commercial Product Assurance[1]
DCC	Data Communications Company
DHW	Domestic Hot Water
DESNZ	Department of Energy Supply and Net Zero
DLMS	Device Language Message Specification, provides an interoperable environment for structured modeling and meter data exchange. Mandated by the GBCS.
DSP	Data Service Provider
DSR	Demand Side Response
EHL	Energy House Lab
ES	Energy Supplier
ESA	Energy Smart Appliance
ESF	Energy System Flexibility
ESME	Electricity Meter
Firmware	Software that provides low-level control of computing device hardware
GBCS	GB Companion Specification. The detailed requirements for communications between smart metering Devices in consumers' premises, and between these Devices and users of the smart metering system (such as Energy Suppliers and Network Operators) via the Data and Communications Company (DCC).
GSME	Gas Meter
HAN	Home Area Network
HEI	Higher Education Institute
HEMS	Home Energy Management System
Home Assistant	Open-source home automation software
HSC	Hardware Smart Energy Company
IET	Institution of Engineering Technology
LCT	Low Carbon Technology (Battery, Heat Pump, Solar, EV charge point)
NCO	Non-Commercial Organisation
NZIP	Net Zero Innovation Portfolio
PCB	Printed Circuit Board
SAPC	Standalone Auxiliary Proportional Controller
SEC	Smart Energy Code

Acronym	Definition
S/HSC	Software & Hardware Smart energy Companies
SMS	Smart Metering System
SMSH	Smart Meters Smart Homes
SMETS	Smart metering equipment technical specifications
SSC	Software Smart Energy Company
TRL	Technology Readiness Level

1 Executive summary

1.1 Project overview

In May 2022, DESNZ launched the Smart Meter Systems (SMS)-based Internet of Things (IoT) Monitoring Solution SBRI Competition. The competition is part of the £65m Flexibility Innovation Programme (FIP) which seeks to enable large-scale widespread electricity system through smart, flexible, secure and accessible technologies and markets.[2] FIP is part of the Net Zero Innovation Portfolio (NZIP).

The aim of the competition was to determine the technical and commercial feasibility of smart meter system-based IoT sensor devices (and any supporting data management tools required). Communication had to be using the existing smart metering network and standards. Funded projects were intended to increase options for either a) the monitoring of 'smart building devices', b) DNO infrastructure assess and c) industrial processes. Hildebrand chose to address the 'smart building device' option and developed the world's first Standalone Auxiliary Proportional Controller (SAPC) device through project SMIOTS (Smart Metering Internet of Things Systems).

The smart metering system currently communicates energy usage data, but while capability exists to retrieve additional sensor data, such as temperature, humidity, inverter performance, EV or battery charge level, etc. that capability had not been exploited prior to this project.[3]

SMIOTS was a three-phase project: key findings and activities per phase are described below.

Phase	Key activities
Feasibility	• Designed the Glow SAPC solution to proof of concept • Demonstrated the feasibility of smart sensing using the DCC Infrastructure by using DCC Boxed (the tool allows users to simulate the DCC infrastructure for device testing) • Developed a set of use cases based on cross energy industry stakeholder engagement
Phase 2	• Firmware and hardware developed for the Glow SAPC; decision taken to develop solution as a two-component solution (Modbus client/server) • Down selection of use cases to use in trial phase; design of trial by Utilita • Use cases informed development of commercial model and full Cost Benefit Analysis (CBA) • CyTAL added to project as CPA certification support provider
Phase 3	• Finalised device development • World-first certifications achieved for the Glow SAPC – Zigbee and DLMS • Updated commercial model and CBA based on project findings • Trial recruitment • Deployed in live homes

Hildebrand led the project, bringing their 17 years of expertise in the energy sector in both hardware development, data management, data analytics (40 billion+ data points stored) and acknowledged excellence in market innovation. Utilita were the energy supplier, they are recognised for having deep experience in the Pay as you Go market. University of Salford and the DCC were key project partners.

1.2 Importance of sensor data retrieval

The ability to retrieve sensor data and communicate that data with suppliers through the existing infrastructure offers numerous potential improvements to the state of the current energy market and the existing smart metering infrastructure. At present, the only information an energy supplier can retrieve from a home is its energy consumption. Suppliers have no visibility of a home's actual conditions such as temperature and humidity, or the performance and status of any installed low carbon technologies (LCTs) in the home. An example of a particular challenge is for vulnerable customers, as currently there is no way of monitoring the temperature in a home to determine whether any retrofit activity has achieved its ambition of improving comfort levels (a use case specific to social housing and landlords investing in improving building fabric).

A further benefit of sensor data retrieval relates to installed Low Carbon Technologies (LCTs) in a home. LCT monitoring is currently typically delivered (if it is at all) by the LCT's manufacturer, meaning that should anything happen to the manufacturer, a resident's installed LCT and monitoring services risk becoming unavailable, and the resident is left in the dark regarding their device's performance and may potentially be excluded from engaging in flexibility. If the retrieval of that data is made available to the resident's supplier, via a SAPC device, this would add a level of confidence to LCT owners by providing a backstop for data access.

1.3 The SMIOTS solution

The newly developed Glow SAPC device connects to the metering infrastructure in a property (home or small business) and transmits sensor data from the property to the energy supplier (temperature and humidity) via the existing smart metering infrastructure. The Glow SAPC can be connected to a bridge device in the home that performs Home Energy Management by reading state and exercising control over technologies like solar inverters, EV chargers, batteries or heat pumps.

The primary use case that was explored during this project and ultimately achieved by the solution is **the retrieval and communication of temperature and humidity data** from an internal temperature and humidity sensor via the **DCC infrastructure.**

It is important to note that the Glow SAPC cannot achieve the use case by itself – over the Modbus communication protocol it connects to a bridge device that in turn talks to sensors and local LCTs. Our SAPC is a Modbus server device; it sends and receives messages to/from a Modbus client device in the property. The Glow SAPC has been designed to be compatible with any commercial Modbus enabled client device.

For this project, testing and trial, Hildebrand used their own Consumer Access Device (CAD), the Glow Delta CAD, as the Modbus client device. A CAD retrieves sensor data for assessment of 'comfort' in the property as well as its real-time **electricity and gas usage**. The Glow SAPC intentionally was designed to offer limited core functionality to ensure it meets the smart metering system's security constraints.

1.3.1 What is a SAPC?

A SAPC device securely controls auxiliary loads within a property; it allows LCT energy consumption loads to be controlled proportionally rather than simply turning them on and off.

SAPCs inform the local control within the home with schedules and proportional control settings, calendar 'schedules' are set by the energy supplier in response to grid level information and energy supplier/services signals, to reliably and at scale communicate with SAPC connected smart devices within the home. The SAPC communicates through the existing smart metering infrastructure to establish connections with network operators and authorised third parties – in this case, the energy supplier.

1.3.2 Why a SAPC device?

While a PPMID device could have been used to retrieve temperature data from a home (a solution that would have been much less complex to implement), it would be limited to that role because it can only send 3 to 4 bytes of data. A SAPC, on the other hand, delivers 384 bytes of data and supports load control in addition to in-property sensor data (temperature and humidity).

The ability to retrieve state data from both the property and any installed LCTs and control the latter provides significant opportunity to address grid stability through managing connected flexibility technologies.

SAPC devices offer the following advantages:

a) Does not require WiFi and is appropriate for homes with no Internet connection, addressing the risk of excluding financially vulnerable households or areas with poor connectivity from flexibility.

b) Can be used as a Demand Side Response (DSR) optimiser, acting to manage energy usage based on DSR criteria with expected cost savings from intelligent control in conjunction with tariff optimisation.
c) Utilises the Smart DCC which guarantees cybersecurity and privacy for all households.
d) Adds value to the DCC infrastructure.

The Glow SAPC offers new market potential, targeting the growing number of properties that will be able to participate in flexibility services. It is important to note that flexibility participation and LCTs are not limited to the ‘able to pay’ market. Social housing providers are actively engaged in determining what technologies to offer and install for their tenants as a key component of addressing their carbon reduction obligations; the SAPC solution offers a trusted, secure, private channel with benefits.

1.4 The Glow SAPC

The benefits of the Glow SAPC vary depending on the installed devices in a property. The table below shows the three levels of functionality delivered by the solution as additional devices are connected.

Level 1 demonstrates the simplest form of the solution, where the SAPC, coupled with a client device and an internal sensor, allows the secure retrieval of the conditions within the home. This is the primary use case of the SMIOTS project and has been achieved.

Level 2 demonstrates how the addition of an LCT permits additional data retrieval, as the conditions and state of the installed LCT can be retrieved as well. The LCT must be connected to the client device via Modbus.

At Level 3, a supplier sets schedules on the Glow SAPC to control installed LCTs in the property. The schedules are set in the context of the property’s conditions, for example, if a heat pump is installed, a supplier can set controls for the device depending on the internal temperature in the home. This represents the added benefit of using a SAPC to implement the SMIOTS solution as it allows suppliers the ability to exert this level of control based on informed information about devices in a home.

Functionality level	Hardware devices	Benefits
1	SAPC + Client device + environmental sensor	• Secure retrieval of conditions in the home (typically temperature and humidity) via the DCC • No reliance on WiFi or other internet connection • Independent of third-party solutions providers
2	SAPC + Client device + environmental sensor + LCT (Modbus connection)	• As above plus ability to return state of the LCT (e.g. charge level of battery)
3	SAPC + Client device + environmental sensor + LCT (Modbus connection) + supplier set calendars	• Set schedules for any LCT devices in situ, taking environmental conditions into account (e.g. Heat Pump control and internal temperature)

1.5 Use cases

During the Feasibility phase of the project, Hildebrand and the University of Salford prepared 15 use cases for the SMIOTS solution, based on contributions from external stakeholders and our own internal expertise in the energy sector and. At the end of the project, Hildebrand and the University of Salford provided a status update on each use case, see full report.

1.6 Current status

At the end of the project, the Glow SAPC and accompanying Glow Delta CAD are live in five properties. Data is being received by the energy supplier (Utilita). Post project completion the intention is to explore

Level 2 and 3 functionalities with project partners and finalise the device based on trial findings before completing full Certified Product Assurance (CPA).

1.7 Looking forward

The development of the Glow SAPC offers the potential for increased monitoring and management of sensor devices and load control while contributing to key use cases around flexibility and support for vulnerable customers. The SAPC provides a new means of accessing data from sensors and smart devices in the property, providing security for the energy consumer by acting as a backstop for existing monitoring systems.

In the case of vulnerable customers, the SAPC solution provides a means for suppliers and their local authority / housing association customers to monitor temperature and humidity in homes to reduce the risk of excluding vulnerable and fuel-poor consumers from flexibility markets and DFS. The sensor data retrieved by the solution can be combined with demographic data to develop indicators for fuel poverty (with all the related data protection considerations in place).

1.7.1 Development of a market

As a new, first of its kind device, the market does not exist yet. Hildebrand now need to establish that market to achieve widespread adoption of the Glow SAPC. See the full report for details.

Dissemination activity from both Hildebrand and project partners will help raise awareness for the new device. By being the 'first of its kind' to achieve produce certification should generate interest which we plan to capitalise to build traction for the solution.

1.7.2 Suggested changes to the smart metering system and regulations

In the existing smart metering infrastructure and regulatory framework, sensor data retrieved by a SAPC can **only** be retrieved by a supplier, and we are years away from required changes being made to the existing system to allow for alternative scenarios.

With only suppliers having access to sensor data and load control, there is minimal flexibility for data access. This scenario also locks energy consumers into supply contracts and load control services and makes considering Change of Supplier more complex, as the gaining supplier may not know how to manage a SAPC device. Alternative scenarios that would give other entities access to this data and the ability to exert load control are required to promote flexibility and interoperability in the market.

1.7.3 Follow up projects

The technical viability of the SAPC has now been proven and the device has been developed, paving the way for new projects as well as the reignition of projects and workstreams that had previously been unfeasible, now that this new technology is about to enter the market.

Future projects involving the Glow SAPC could include field trials surrounding heat pump (or other LCT) control, and implications for flexibility and DSR.

1.8 Conclusions

The successful development of the SMIOTS solution and the technical development of the Glow SAPC have substantial implications for monitoring and management of smart sensing IoT devices, as well as flexibility and grid stability, opening the door for further innovation that will build on this new technology.

2 Background

This section provides information for the reader who may not be familiar with the challenge DESNZ posed to the market, the UK smart metering system, communications technologies relevant to achieving flexibility and related projects and standard developments.

2.1 The DESNZ challenge

DESNZ launched the Smart Meter Systems (SMS)-based Internet of Things (IoT) Monitoring Solution SBRI Competition in May 2022. The competition is part of the £65m Flexibility Innovation Programme (FIP) which seeks to enable large-scale widespread electricity system through smart, flexible, secure and accessible technologies and markets.[4] FIP is part of the Net Zero Innovation Portfolio (NZIP). The following narrative is almost verbatim from the SBRI competition guidance notes.

2.1.1 Background

An SMS-based IoT monitoring solution would support the Smart System and Flexibility Plan[5]'s policy principles of **interoperability, data privacy, grid stability and cyber security**, by providing a **single secure and interoperable platform** for current and new IoT applications, in a range of domestic, business and industrial environments.

The IoT applications of interest focus on the optimisation of assets in line with the low energy use and measurement requirements of the Net Zero Carbon Buildings Framework.

In addition, efficient use and protection of the distribution network will play a vital role in the adoption of energy-efficient technologies including the electrification of heating and transport. This will entail IoT-based monitoring and management for local thermal constraints and system balancing, with commensurate cyber security protection requirements.

2.1.2 Competition aims

The aim of the competition was to determine the technical and commercial feasibility of smart meter system-based IoT sensor devices (and any supporting data management tools required). Communication had to be using the existing smart metering network and standards. Funded projects were intended to increase options for the monitoring of 'smart building devices', DNO infrastructure assess and industrial processes.

2.1.3 Beneficiaries and target benefits

As defined by DESNZ:

Beneficiaries would include	Target benefits are
• Consumers • Demand Side Response Service Providers (DSRSPs) • Energy Suppliers • Energy Management Service Providers • Grid Operators • Other Industry Users	• An alternative route for monitoring via an already ubiquitous platform with universal interoperability; • Consumer independent connectivity (no reliance on consumer broadband etc.); • Minimal additional cost; cost savings compared with alternatives; and • Easy integration with smart meter energy data.

2.1.4 Target outcomes

DESNZ targeted outcomes were:

- Accelerated commercialisation (of SMS-based IoT-related DSR products and services), leading to:
  - Increased system flexibility; and
  - Increased uptake of low carbon solutions

2.1.5 Competition objectives

DESNZ's key objectives for this Competition were to:

- Evaluate potential use of the SMS network as a route for monitoring sensors in application areas such as smart buildings, industrial processes and Distribution Network Operator (DNO) infrastructure assets (e.g. Low Voltage substations);
- Develop a proven solution for sensor devices (and any required data management tools) that users can manage via the SMS network;
- Create a pre-commercial reference design for such devices and supporting systems that may be further developed for full commercial development;
- Identify the specific benefits and challenges of using the SMS DCC network for these applications; and
- Identify any technical and regulatory changes that may be required for suggested improvements.

2.2 The UK Smart metering system

The UK's smart metering system (SMS) is depicted below; 60% of all domestic meters were smart meters operating in smart mode at the end of December 2024.[6] As the flexibility market develops the SMS delivers the infrastructure and governance to support the drive to net zero.

The diagram below provides an overview of the key components of the SMS and the infrastructure and governance in place to ensure a secure and stable system.

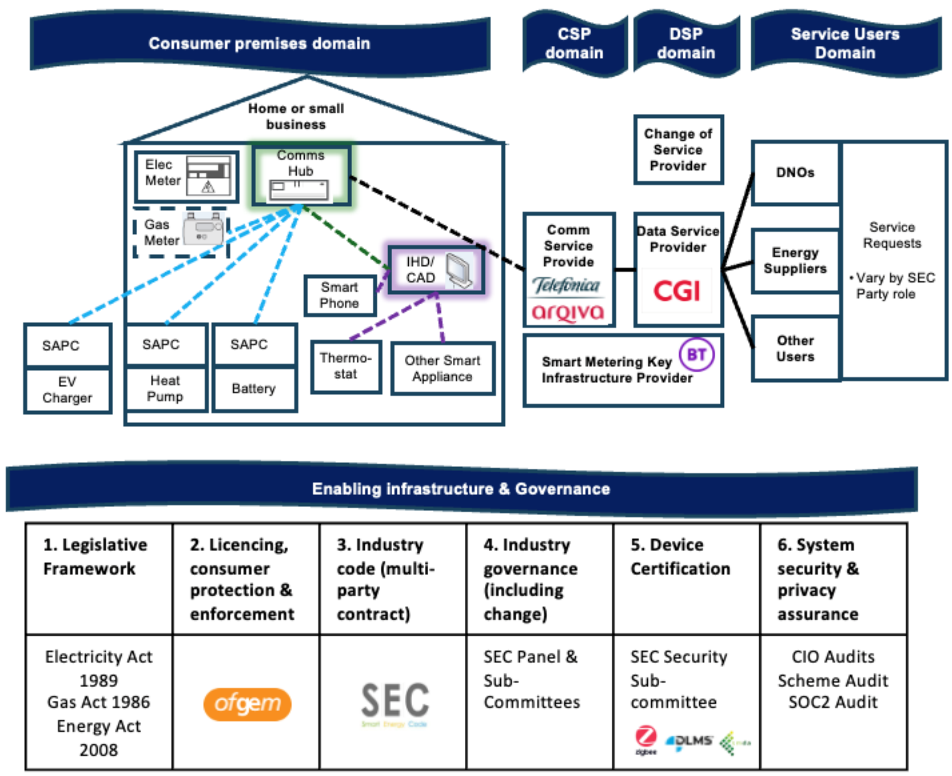

Figure 1. UK Smart Metering System and Governance, Source: DESNZ

2.2.1 How the SMS works

Within the property (domestic and smaller non-domestic) a Home Area Network (HAN) is established between the Communications Hub and the electricity meter over the Zigbee protocol. Gas meters also communicate over Zigbee - the gas meter is battery powered and installed in communication range of the Communications Hub.

When smart meters are installed, the engineer commissions the meters, the Communications Hub and the In-Home Display (IHD) and establishes the HAN. The HAN is connected to the Wide Area Network (WAN); the WAN is the channel used to retrieve data from the meter(s). The Data Communications

Company (DCC) is responsible for managing the secure infrastructure that allows authorised parties (energy suppliers and 'Other Users') to retrieve (encrypted) data from the meters.

2.2.2 Governance

The Smart Energy Code (SEC) is the multi-Party agreement which defines the rights and obligations of energy suppliers, network operators and other relevant parties involved in the end-to-end management of the SMS[7].

Service users that have access to the meter (energy suppliers and other users) must comply with the SEC's security obligations; the other user role also has to meet the SEC's privacy obligations. Each of these user types is independently assessed by the User Competent Independent Organisation (User CIO). The User CIO, currently Deloitte LLP, is appointed by the SEC Panel to undertake security and privacy assessments on their behalf[8]. Security and energy consumer protection is paramount.

2.2.3 Metering and devices

Meters must meet the requirements of the Smart Metering Equipment Technical Specification (SMETS); meter compliance is the responsibility of the SEC. There are devices that can be connected to SMETS meters: a Type 1 device is **a HAN Connected Auxiliary Load Control Switch or a Pre-Payment Meter Interface Device**. A Type 2 device is a device that does not store or use the Security Credentials of other devices for the purposes of communicating via the HAN.[9] (In the diagram above an In-Home Display that can take pre-payment instructions is a Type 1 device; a Consumer Access Device (CAD) is a Type 2 device).

To date, no-one has developed a **Standalone Auxiliary Proportional Controller** - until now. This report is about how, with DESNZ funding via the NZIP programme, Hildebrand designed and delivered the first certified **Standalone Auxiliary Proportional Controller** (SAPC) device of its kind in the world. A SAPC is a Type 2 device.

2.2.4 Communications between smart metering devices

The Great Britain Companion Specification (GBCS) describes the detailed requirements for communications between Smart Metering Devices in consumers premises, and between Smart Metering Devices and the Data and Communications Company (DCC).[10] It is based on international standards (Zigbee Smart Energy Protocol, DLMS, etc.) and adapted to meet GB requirements.

2.2.5 Energy consumers: benefits of the SMS, yesterday, today and tomorrow

Yesterday: when the smart meter rollout started in the mid-2010's consumers saw immediate benefit from no longer having to take meter readings; their energy supplier could retrieve the readings over the SMS infrastructure. Switching to a new energy supplier became much quicker and easier because the consumer's consumption history was up to date and accurate.

The SEC mandates important principles to support energy consumers’ rights, including asserting they:

1. own their energy consumption data (not the energy supplier) and decide who has access to it, and
2. have the right to have a third-party device connected to their meter to retrieve real-time consumption data without needing energy supplier rights.

The SEC give energy consumers freedom of choice and removes their reliance on the energy supplier as their only option for data. The Other User (OU) role is one that provides the 'beyond the supplier' functionality meter access to the energy consumer. With consumer verification and consent in place, the OU can retrieve the consumer's half hourly data on their behalf, making it available to the consumer through Apps, websites and Application Programming Interfaces (APIs). An OU is also able to send the instruction to join a Type 1 device (like a CAD) to the meters (via the WAN/HAN); an OU **cannot** join a Type 2 device to the meter, only a supplier has permission to do this. (This is an important point to keep in mind with respect to the SAPC).

Today: the ubiquity and security of the SMS and its grid integration mean that energy consumers with smart meters can participate in the flexibility markets; the Demand Flexibility Service (DFS) helps households and qualifying businesses participate in the electricity market by providing incentives, through suppliers and aggregators, for reducing or shifting demand.[11]

Tomorrow: currently consumers' participation in flexibility typically requires active engagement (manually turn on/off/down). In future, effective flexibility will be automated, with low carbon technologies (LCTs) like battery, heat pumps, EV chargers, responding to grid events without human intervention. End to end data flows from DNO, to supplier, to property, to LCTs with scheduled import/export instructions can be delivered securely without reliance on third parties, using a SAPC device via the SMS.

2.3 Communications protocols

The smart meter system, the SAPC solution, and flexibility assets use a number of communication protocols that may be new to the reader.

Protocol	Description
APIs	An Application Programming Interface (API) is a set of protocols that enable different software components to communicate and transfer data.[12]
Modbus	Modbus is a client/server data communications protocol[13] that operates between automation devices. It is openly published and royalty free. Modbus supports communication to and from multiple devices connected to the same **cable**. It is commonly used across industrial and metering applications.
Modbus client	A Modbus client initiates a transaction to request a task from its server; sends instructions to and from the connected server(s). Formerly known as the master device.
Modbus server	A Modbus server receives requests from the client and actions them. Formerly known as the slave device.
Modbus register	Modbus data is typically read and written as ‘registers’: a register is a 16-bit piece of data.[14]
Zigbee	ZigBee is a secure wireless network used for communication between smart devices that have adopted the protocol. It is the protocol used for the GB smart meters and communications hubs to communicate with each other and any connected Type 1 or Type 2 devices.
NbIoT	Narrowband Internet of Things is a communications protocol that uses low power, wide area radio technology.[15] It enables a broad range of new IoT devices and services; it is recognised for reducing the power consumption requirements of connected devices while increasing system capacity and bandwidth efficiency particularly in locations that aren’t easily covered by traditional cellular technologies.
LCTs	Low Carbon Technologies include batteries, solar inverters, EV charge points and heat pumps. They usually communicate their current state through APIs or Modbus wired connections.

2.4 Relevant projects and industry initiatives

Below we summarise activities relevant to the SMIOTS project; they reflect the current landscape within which a SAPC device could add new opportunities to expedite the drive to flexibility.

2.4.1 SMETERS: Smart Meter Enabled Thermal Energy Ratings

In 2020 DESNZ funded innovation, via the SMETER programme,[16] to explore the value of using temperature data alongside smart meter data to calculate buildings’ thermal efficiency ratings. The government aims to assess thermal properties of domestic building stock. The key parameter that characterises the rate of heat loss capacity of built stock is heat transfer coefficient (HTC). That figure can be used to support building retrofit assessments, performance monitoring and financing.

2.4.2 OpenADR: Open Automated Demand Response

OpenADR is a non-proprietary, open, standardised and secure demand response (DR) interface that allows electricity providers to communicate DR signals directly to existing customers using a common language and existing communications such as the internet.[17] While OpenADR defines a protocol, there is no assumed operating model, whereas SMIOTS uses the governance, infrastructure and operating model of the GB smart meter system to realise demand response and load control.

2.4.3 Technical standards for electrical appliances to engage in Demand Response

PAS1878 and PAS1879 are standards that were sponsored by government in 2021 through an industry-led process to technical requirements for Demand Side Response (DSR) enabled energy smart appliances.[18] The appliances are capable of responding automatically to signals (price or direct control) by shifting or modulating their electricity consumption, storage, and/or production. Examples include EV charge points, domestic battery energy storage systems, heat pumps, solar panels with 'smart' storage.

3 Project overview

3.1 Project participants

3.1.1 Hildebrand

Project lead Hildebrand was one of the first DCC Other Users (2019) and has been supporting customers (retail, commercial, academic and government) with energy related data services and devices – including the Glow CAD – since 2005. Hildebrand are unique, they develop their own hardware, data ingestion (currently captured over 350 billion energy consumption readings), analytics and front-end applications.

Hildebrand is ISO27001 certified and brings expertise in the energy sector, innovation, product design and development, security and project management. Current customers include The Isle of Man (smart meter data retrieval, management and billing (prepay and credit), Uswitch, Drax, Energy Systems Catapult, Vital Energi (heat metering devices, data retrieval, management and billing (prepay and credit).

3.1.2 Sub-contractors

Subcontractors DCC, the University of Salford and Utilita all played a significant role on the project.

The Smart DCC (**Data Communications Company**) manages the smart metering infrastructure, with their role on this project being to advise on the technical viability of the proposed SAPC device, cybersecurity, data privacy and potential user applications and use cases for the proposed device.

The **University of Salford** is home to the Smart Meters > Smart Homes (SMSH) lab which is one of the four Energy House Labs (EHLs). The Salford Smart Home (SSH), which is the lab facility of the SMSH, was utilised for SMIOTS. SSH is a live testing house and has testing capabilities against several Modbus controllable devices as well as sensor technology. The SMSH lab contributed to the Use Case development throughout both phases of the project as well as to the testing of the SAPC and the Delta devices.

Utilita were added to the project in Phase 2, their role was to deliver and manage the trial homes for the trial phase of SMIOTs. Utilita are Britain's leading Pay As You Go (PAYG) supplier. During the develop phase, Utilita contributed to the development of both use and business cases. As part of the Trial phase, they further developed these cases, the Cost Benefit Analysis (CBA), and designed the user journey, including specifying their requirements for the engineers' device installation instructions and customer support. Utilita delivered and managing the five trial homes for the trial.

CyTAL, although not a project sub-contractor, played a key role as the chosen supplier of the Commercial Product Assurance (CPA) Test House for SMIOTs. CyTAL's ProtoCrawler tool was invaluable for firmware testing during the development cycle, providing ongoing reassurance with each cycle that functionality worked as expected.

3.2 Project synopsis and progress across phases

SMIOTS was a three-phase project: key findings and activities per phase are described below. Down selection after Phase 1 (Feasibility) took the total number of successful projects participating in the programme from five to two.

Phase	Key activities
Feasibility	• Designed the Glow SAPC solution to proof of concept • Demonstrated the feasibility of smart sensing using the DCC Infrastructure • Developed a set of use cases based on cross energy industry stakeholder engagement
Phase 2	• Firmware and hardware developed for the Glow SAPC; decision taken to develop solution as a two-component solution (Modbus client/server) • Down selection of use cases to use in trial phase; design of trial by Utilita • Use cases informed commercial model version 1 and full Cost Benefit Analysis (CBA)

Phase	Key activities
	• CyTAL added to project as CPA certification support provider
Phase 3	• Finalised device development • World-first certifications achieved for the Glow SAPC – Zigbee and DLMS • Updated commercial model and CBA based on project findings • Trial recruitment • Deployed in live homes

3.2.1 Feasibility phase

During Feasibility Hildebrand's primary activity was to design the proposed SMIOTS solution and demonstrate the feasibility of smart sensing using the DCC smart metering infrastructure. We successfully demonstrated the transfer of embedded IoT data (in this demonstration, specifically temperature and humidity sensor data from inside the property was retrieved and transferred) via the DCC network using DCC Boxed (a portable testing tool developed by the DCC that emulates the smart metering infrastructure in a self-contained environment) without impacting or connecting to the live environment. The key technical finding was that the billing payload could be used to carry the data (see next section for a full explanation of the billing payload).

Hildebrand and the University of Salford developed 15 use cases for the SMIOTS solution through external stakeholder engagement (survey and interviews) and within the team; stakeholders represented key roles in industry including energy suppliers, LCT providers, academics and consultants. See Section 5 Use Cases for a summary of our conclusions at project completion.

3.2.2 Phase 2

Phase 2 of the project saw the development of the Glow SAPC (firmware and hardware) and the SMIOTS solution, during which two key decisions about the solution were taken. The first was to develop the SAPC as a two-component solution, with the Glow SAPC as a Modbus server and a separate Controller device serving as the Modbus client. This decision was taken to de-risk the Commercial Product Assurance process by isolating the unit's connectivity (beyond the Zigbee) to a single physical Modbus wire to the Controller unit.

The second decision was to not include the DCC Other User (OU) role as a party that can receive messages from the SAPC device; this decision was driven by practicalities as the SEC is currently written to mandate that the data must go back to the energy supplier. Amending the SEC to extend to adding the OU role would take years. In the What comes next? section we consider what would need to change in future for the SAPC to be extended beyond the supplier role.

From the use cases defined in Feasibility, five were selected as the priority use cases for the remainder of the project and for the SAPC: measured fabric performance, heat pumps, batteries, EV, and DSR. These were used to inform trial planning in this phase and in Phase 3.

Hildebrand also developed the first iteration of a Cost Benefit Analysis (CBA) for the SMIOTS solution and the SAPC – this was refined over the project. See Section 6.3 CBA for final findings and updates.

During this phase, Hildebrand began working with CyTAL, an NCSC assured test lab, to support CPA preparation and testing.

3.2.3 Phase 3

Device development, testing and deployment for Trial occurred in Phase 3, with many significant milestones achieved. Hildebrand, with the help of Arista (UK based manufacturing company), finalised the housing and secure manufacturing process for the Glow SAPC; Arista built an initial short manufacturing run for the device to support Trial installations and the CPA process (which includes testing physical devices to ensure they meet the standard).

Firmware development continued, culminating in the achievement of ZigBee and DLMS certification for the Glow SAPC – a world first in both scenarios. The SAPC was successfully installed and commissioned in test environments at the DCC Test Lab and Utilita's test environment. Followed soon after by installation in live environments at the University of Salford's Smart Energy House with an Alfan EV charge point, Giveenergy battery and Home Assistant and Utilita's test facility with live meters.

The original project timeline was too ambitious with respect to having an installation ready product; the Trial phase had to be reduced from several months to less than a fortnight. The Glow SAPC is currently live in five properties at project conclusion.

Despite timeline challenges, the key project goal was met: we demonstrated the key use case of the project: retrieving and transmitting sensor data from a property via the DCC infrastructure.

4 The SAPC solution

The project achieved DESNZ's objective of acquiring non-energy data from a property and returning it over the DCC network by developing a Standalone Auxiliary Proportional Controller (SAPC) device. The device is a general-purpose transport mechanism for encrypted data. Because it is a SAPC, the device provides the potential for additional benefits, specifically load control by the energy supplier.

Glow SAPC, front cover removed

Glow SAPC, front cover attached

4.1 What is a SAPC?

The primary purpose of a SAPC device is to securely control auxiliary loads using up to five Auxiliary Controllers, one of which must be an Auxiliary Proportional Controller, which allows loads to be controlled proportionally rather than just on/off. A SAPC device is intended to be installed in domestic premises and smaller non-domestic consumer premises which have a SMETS2 smart meter.

As part of the GB smart metering system, the SAPC can be deployed at the energy consumer’s premises along with other equipment. It communicates through a Smart Metering Home Area Network (HAN) with a Communications Hub. The Communications Hub also provides communications between the HAN and the smart metering Wide Area Network (WAN). The WAN connects the Communications Hub to the Energy Supplier via an access control broker, the DCC, which also establishes connections with network operators and authorised third parties.

SAPCs inform the local control within the property with schedules and proportional control settings, set by the energy supplier in response to grid level information and energy supplier/services signals, to reliably and at scale reach assets within the home.

4.2 Rationale for choosing SAPC over a PPMID implementation

4.2.1 PPMID analysis

The option of using a PPMID device (an in-home display used to capture prepayment) to retrieve sensor data was considered during the Feasibility phase but rejected[19] as being technically unsuitable to achieve our ambitions because:

- According to Table 279 of the DUIS Interface Specification version 5.3, a PPMID can only deliver a single alert type which is a Firmware version alert that could be used for general purpose data. The other alerts that could be generated would either fail validation, not have any un-used space or cause operational disruption as those alerts are critical to manage the PPMID. We believe that repurposing any of the following possible alerts would have an adverse effect on the smart metering system:

  8F1E: Communication issue with the meter

  8F30: Prepayment system error

8F3D: Configuration mismatch

8F3E: Low credit warning

8F3F: Credit validation error

8F78: Tampering detected

8F8B: Communication/system timeout

    - A Firmware alert is suitable, because the firmware version number can be set by the PPMID itself and will not interfere with system operation. However the Firmware version alert is very small with 3 bytes used to encode the firmware version. There is only enough space to send temperature data, nothing more.
- Alerts are routed to the energy supplier and not accessible through any other route: constrains the option of delivering data to other stakeholders in the system.
- PPMID alerts have to be checked by the Data Service Provider (DSP): this risks alerts being inspected and rejected by the DSP and not getting to their destination (the supplier).

4.2.2 SAPC benefits over a PPMID device

The proportional load controls scenarios a SAPC delivers are of particular interest to achieve flexibility but also have a benefit of more features to send data back through the DCC. The use cases for mixing flexibility services and data coming back through the DCC are complementary. For example batteries, could signal the network on amount of charge to be stored / taken using the DCC as a communications channel. This goes beyond simple temperature payloads and into intelligent control.

A SAPC delivers the following benefits:

- 384 bytes can be transferred in the alert package (delivered via a Build Log Alert, our selected data delivery mechanism): large enough to support load control
- Messages are not checked by the DSP: won't be rejected en route to the supplier
- Message are encrypted: the DCC cannot intervene as they have no ability to inspect (or reject)
- Modbus which is commonly found on low carbon technology devices can be included on the SAPC device: provides a channel for external dialogue

A SAPC is a Type 1 device; a PPMID is a Type 2 device.

4.2.3 Chose the SAPC over the PPMID

The PPMID option offers an advantage over the SAPC – it does not have to be taken through Commercial Product Assurance (CPA) because it is not directly connected to the metering system, unlike the SAPC. CPA is an expensive (costs over £100K) and time-consuming (minimum of six months) process; the project took the decision that the functional benefits offered by the SAPC merited that investment.

The SAPC offers new market potential, targeting the growing number of homes and businesses that will be able to participate in flexibility services. It provides a significant opportunity to increase overall utility beyond a PPMID device.

Note: flexibility participation through low carbon technologies (LCTs) is not limited to the 'able to pay' market, social housing providers are actively engaged in determining what to offer / install for their tenants. For example, larger batteries can be purchased by the landlord to provide resilience and more affordable energy to tenants by charging from the grid when electricity is cheaper (off-peak) and discharging when it is more expensive (peak).[20]

The SAPC solution offers a trusted, secure, private (due to the DCC network) channel that could act to ensure that LCT assets don't risk being hidden within a 'walled garden' or stranded. An example of a 'walled garden' in this context is an LCT provider's own, closed, ecosystem used to manage their technology and control charge/discharge. Each LCT could be in its own ecosystem so solar inverter, battery, EV charge point could all be managed separately with no data flows between them; this is not ideal for local system optimisation. If an LCT provider goes out of business, the asset they installed risks being completely inaccessible as the software that ran it is will no longer operate – the asset is stranded – the SAPC could provide a 'backstop' to that risk.

It is important to note that today the SAPC can only send data to a supplier, with changes to the Smart Energy Code (SEC), data could be sent to other organisations with appropriate permissions. This topic is discussed in the What comes next? section of this report.

4.3 The Glow SAPC

The developed Glow SAPC delivers load control. The first SAPC device in the world, it also delivers innovation in how it provides a backchannel to the DCC infrastructure by delivering data using the billing alert channel/functionality. The Glow SAPC is a transmitter of key information from the property including temperature, humidity, solar inverter performance, EV or battery charge level, or heat pump status. These are critical inputs to optimising load control, the need to retrieve status data from LCTs drove our decision to use a SAPC device for the solution.

A SAPC device, as currently specified, doesn't act alone; it requires a client/controller device to provide the intelligence between the SAPC and the sensors / LCTs from which a) data is being retrieved and b) control is being exercised. We refer to this client as a HEMS (Home Energy Management System) device.

Communication between devices in our approach uses the Modbus protocol which connects devices in the property, retrieves data and effects load control. To enforce security requirements for SAPC devices, we made the SAPC Modbus interface a server device with limited interface functionality[21]. The Glow SAPC device includes a physical slot for a cable that connects to a client/controller device; communication is via the Modbus protocol.

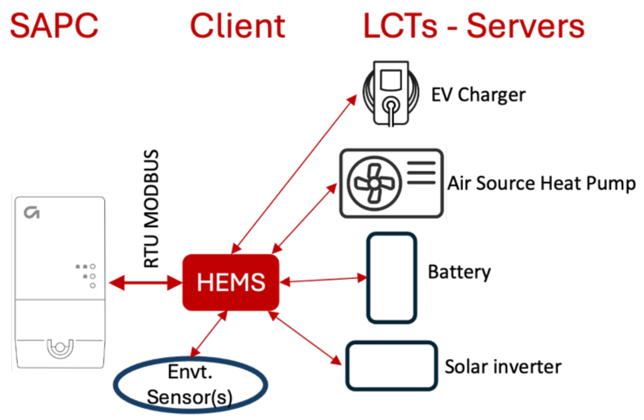

Figure 2. SAPC, Client and LCT devices (which are servers in a client / server relationship) demonstrating using of Modbus

The Modbus client sends commands and instructs inverters, batteries, EV chargers, heat pumps or other demand side technologies; it also retrieves data from the connected Modbus devices and delivers the data, via the SAPC, back over the smart metering system network using the billing alert functionality described above.

When coupled with a client device that acts as a bridge between the Glow SAPC and any LCTs or smart devices in the home the SAPC can retrieve data from up to five LCTs (with Modbus outputs) and control them based on schedules set by a supplier. A final level of connectivity intelligence is added by integrating a Home Energy Management System (HEMS); a HEMS is a digital system that monitors and controls energy generation, storage and consumption within a household. HEMS usually optimise for a goal such as cost reduction, self-sufficiency maximisation or emissions minimisation.[22]

4.3.1 GBCS compliance

The Glow SAPC is GBCS compliant as prescribed by the Smart Energy Code (SEC). The Great Britain Companion Specification (GBCS) describes and outlines the requirements for communications between smart metering devices in consumers' properties, as well as communications between these devices and the DCC.[23]

Note: The interface between a SAPC device and the load-controlled device has not been defined within GBCS specifications. It was intentionally left up to manufacturers to develop their own specifications to prevent stifling innovation. Hildebrand's Glow SAPC chose Modbus.

4.4 Two component solution

The Glow SAPC solution has two components a MODBUS client and the SAPC device acting as a MODBUS server. Other low carbon technologies such as batteries and EV charge points would also be MODBUS servers. The rationale behind this decision is to give suppliers, aggregators or energy service providers the ability to source the most appropriate Modbus client device to act as a home energy management system for their purposes, while the SAPC is open as a MODBUS server. Specifically,

Component 1. Glow SAPC device: connected to the CH at the property, installed by an engineer (Modbus server)

Component 2. Controller device: sits within the property and has a Modbus wired connection to the SAPC device (Modbus client). Can then be connected to other technologies in the home including environmental sensors and low carbon technologies in situ (using a range of communication protocols including APIs, Bluetooth, Modbus).

4.4.1 Glow Delta - acting as the Home Energy Management system (HEMS)

For this project Hildebrand used our new Glow Delta CAD as the client / controller but any commercial client device could be used instead. The Glow Delta CAD interfaces via a Modbus connection to the SAPC and LCT devices where they are in server roles. It is the Delta that is a client in that it is reading and writing data on to a number of MODBUS server devices, including the MODBUS server that is the SAPC device. The data that has been retrieved from sensors and LCT devices that are servers can then be written back to the SAPC MODBUS server, making the Glow Delta CAD the HEMS device. The Delta is bridging and coordinating between various devices.

The Delta also acts as a traditional Consumer Access Device (CAD), connecting to a smart meter to retrieve **real-time electricity** and **gas** data from a property's meters; this functionality is not in the Glow SAPC. The Delta's ability to report data over NB-IoT is beneficial; by eliminating the need for WiFi connectivity to retrieve real-time smart meter data at a property it makes flexibility more accessible for homes with poor/no WiFi connectivity thus helping to ensure that the vulnerable who may be less likely to have constant WiFi are **not** excluded from future flexibility services.

A controller device that is a CAD importantly offers the ability to retrieve sensor data for assessment of 'comfort' in the **context** of the property's **electricity and gas usage**. The Glow SAPC cannot join to an electricity or gas meter and thus cannot retrieve that data, even though consumption data provides important context to the sensor data being retrieved.

4.4.2 Enabling technologies

4.4.2.1 Home Energy Management System

While any Home Energy Management System (HEMS) can be used, Home Assistant was used for the project. Home Assistant[24] is a free, open-source (and popular) home automation software that allows users to integrate, access and control their smart home devices from a centralised gateway. The home automation solution works with the client device, supporting control of multiple LCT devices via whichever interface they utilise (Modbus or API).

4.4.2.2 Sensors

The primary objective of the project is to retrieve sensor data from a home and communicate it via the DCC infrastructure. Environmental sensors readings are captured via the Modbus client device wired to the SAPC and then communicated to the supplier via the DCC infrastructure. See the Use Case section for a review of how sensor information can be valuable and used.

4.5 Data flows

The following diagrams demonstrate the secure data flows delivered via the Glow SAPC back to the energy supplier.

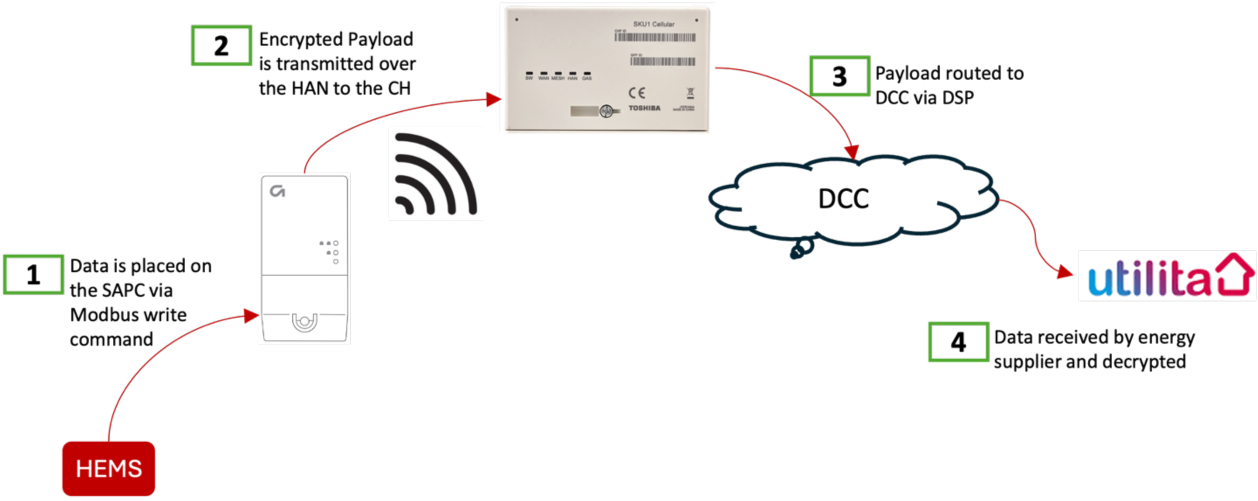

Figure 3. Dataflow from Client/HEMS back to supplier

The optional ability to exert load control via the SAPC, through scheduled load control instructions set as calendars by the supplier, is represented below.

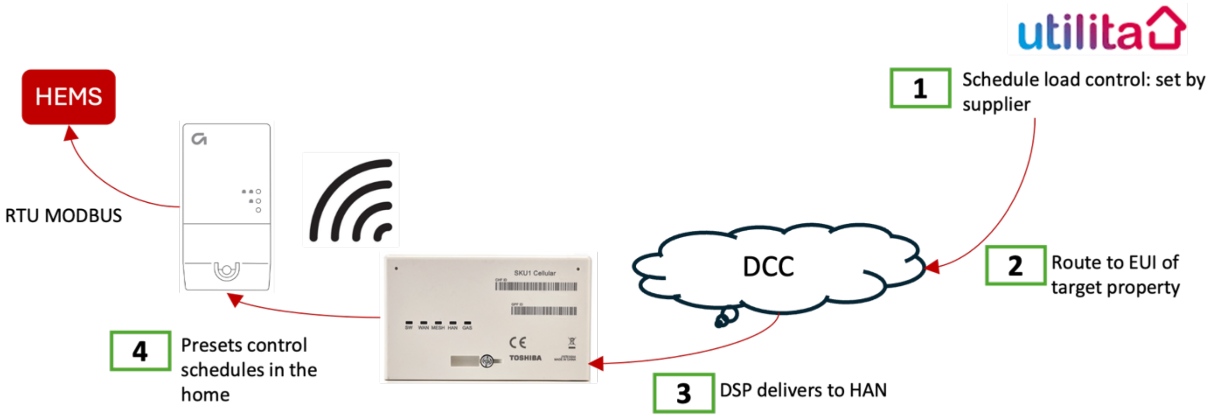

Figure 4. Dataflow from supplier back to the SAPC device and Client / HEMS

4.6 Device development

During the final phase of the project the firmware and hardware components of the SAPC were developed and finalised.

4.6.1 Firmware

The Glow SAPC firmware was developed in-house by Hildebrand's hardware team.

4.6.1.1 Firmware testing using ProtoCrawler

ProtoCrawler is intelligent fuzz testing software that CyTAL provides under license.[25] Originally developed to support functional compliance testing and CPA evaluations ProtoCrawler is now integrated into the workflows of CyTAL customers, to support CPA processes – it is an established industry tool. CyTAL use the product to discharge their testing obligations under CPA. The tool was key to device development: it supported significant de-risking of the formal CPA evaluation activity by providing confidence that functionality worked as required and met the CPA standard.

4.6.2 Hardware

4.6.2.1 Housing

Housing design for the Glow SAPC evolved throughout the project – for a schematic of the final housing design, see Appendix 1. Initial tooling and prototype plastics were manufactured in China and were refined based on feedback from Utilita and inhouse testing. Once finalised, the physical tool required to produce the housing (three separate parts) was sent to Arista's factory so that future manufacturing runs could be completed in the UK at Arista.

4.6.2.2 Manufacture

The Glow SAPC is manufactured by Arista Electronic Systems located in High Wycombe. Arista's manufacturing standards and our pre-existing positive working relationship made them a clear choice for producing the SAPC. Any device that has achieve CPA must deliver a high level of security in the manufacturing process and for the device itself; for example, the two main plastics of the Glow SAPC (top and bottom, that contain the board (PCB) with the electronic components) must be sonically welded to prevent the device from being accessed. Note: security requirements state that tampering must trigger an automated alert (achieved by the firmware). Arista's facilities meet the required criteria for security and deliver the processes required to meet the CPA's secure production environment standards.

4.6.3 Certification

4.6.3.1 ZigBee certification

ZigBee certification is required for any meters and connected devices in line with the GB smart metering system standards. The **Glow SAPC** was **ZigBee certified** by the Element test house during Phase 3 in June 2024 – it is the **first SAPC** device to receive ZigBee certification.

4.6.3.2 DLMS certification

DLMS (Device Language Message Specification) is an international standard that ensures interoperability and compliance between different meters and systems. GBCS requires certification from the DLMS UA (User Association) for a SAPC.[26] *Note:* DLMS Certification was also required to achieve the Trial Device Certificate from the SEC Security Sub-Committee – see next section.

The Glow SAPC achieved DLMS Certified Compliance in February 2025. It is the **first SAPC device to go through DLMS Certification** – no guidance existed on how a SAPC should be tested using the required DLMS Test Tool to achieve certification. Being first was challenging enough, additional significant unexpected challenges in passing could not have been anticipated due to major changes announced by the DLMS UA in late October 2024 (license fee increase x10, new testing tool).

4.6.4 Security Sub-Committee (SSC) waiver for trial

A Type 1[27] device must be CPA certified before it can be installed on a live/production energy supply. Recognising that achieving full CPA prior to project conclusion was unlikely we sought a waiver from Security Sub-Committee to allow us to install the Glow SAPC in a live environment through what is known as a **Trial Device Certificate**. Hildebrand chose to pursue this waiver for two reasons:

1. A substantial portion of firmware development was outstanding when we applied for the Certificate in September 2024, but not relevant to trial; trial objectives could be met without that firmware in place. **Note**: firmware is now complete.
2. The ability to install and observe the device in a live environment provided an assurance phase before finally officially submitting the device for CPA certification.

With respect to point 2, it would be expensive to go through CPA and then find that in a live scenario, the Glow SAPC does not behave as expected, requiring a firmware update and a second (expensive) pass at CPA. The Trial Device Certificate de-risks this.

Hildebrand's application for the Certificate was submitted in September 2024 and included evidence of the state of the device's development and the associated risks of going into trial in the device's current state. The application was approved, on the basis that Hildebrand provide additional documentation, including ZigBee and DLMS Certification for the Glow SAPC. On achieving DLMS Certification the Trial Device Certificate was officially issued to Hildebrand on 20 February 2025, valid for six months.

4.7 Achieving CPA

The Commercial Product Assurance (CPA) scheme was set up to help manufacturers demonstrate that the security functions of their products (smart meters or recognised smart metering products) [28] meet the defined standards - known as Security Characteristics and comply with the GBCS. **Note**: CyTAL takes over the CPA Scheme Operator role in Spring 2025.

4.7.1 Overview of CPA certification

The CPA scheme gives companies a way of having their product tested to show that the security claims they make about their product can be independently verified. [29] Documentation is submitted, including the Technical Design Document, Build Standard and manufacturing process description in conjunction with the physical device. CyTAL will submit the following evidence to the current Scheme Operator, NCSC, when they are satisfied the device should pass the required tests.

4.7.1.1 Firmware

CyTAL will use their ProtoCrawler tool to test the firmware. (For the record, Hildebrand selected CyTAL as their CPA support provider long before CyTAL went through the procurement process to take over from NCSC.)

4.7.1.2 Build Standard

Hildebrand prepared a Build Standard document to describe how the thirteen requirements that must be met were delivered.

4.7.1.3 Technical Design Document

The Technical Design Document for the Glow SAPC was updated throughout the project. The final version is part of the CPA.

4.7.1.4 Audit and testing

The manufacturing facility will be audited by CyTAL. Several devices will be put through physical testing (automated alerts must be triggered if any tampering happens) to confirm they meet the required standard. Hildebrand development staff will be audited via interview to ensure required development standards were followed, as evidenced by the Build Standard.

4.7.1.5 Next steps

Trial findings may result in further product modification; particularly to the physical form factor. When the product is final, we will submit for CPA.

4.8 What a SAPC cannot do

It is important state what a SAPC device, as currently specified, cannot do:

- Read the electricity or gas meter(s)
- Act independently between a sensor / LCT - some form of Client device is required in between the LCT (a server device) and the SAPC
- Behave as a Consumer Access Device (CAD) and report real-time energy

4.9 Conclusion

The Glow SAPC is the first ZigBee and DLMS certified device of its kind in the world. Once Trial findings are collated and reviewed the product will be finalised and submitted for CPA.

The solution aligns with Demand Side Response (DSR)[30] ambitions to help balance the UK's electricity system. Automated Demand Response (ADR)[31] will be key – a SAPC device offers the potential to facilitate the dialogue between the electricity grid and the property (home or business).

4.9.1 Functionality demonstrated: today and tomorrow

At project completion the Glow SAPC has demonstrated the core functionality by retrieving environmental sensor data from within the home (Level 1 below) and reporting it back via the DCC. In the next weeks, the Glow Delta will be connected to a heat pump and an EV charge point to retrieve device 'state' and report it back (Level 2). Finally, the intention is to support Utilita in setting calendars on the SAPC to set schedules for charge / discharge and send those instructions to the connected low carbon technologies (Level 3).

Functionality level	Hardware devices	Benefits
1	SAPC + Client device + environmental sensor	• Secure retrieval of conditions in the home (typically temperature and humidity) via the DCC • No reliance on WiFi or other internet connection • Independent of third-party solutions providers
2	SAPC + Client device + environmental sensor + LCT (Modbus connection)	• As above plus ability to return state of the LCT (e.g. charge level of battery)
3	SAPC + Client device + environmental sensor + LCT (Modbus connection) + supplier set calendars	• Set schedules for any LCT devices in situ, taking environmental conditions into account (e.g. Heat Pump control and internal temperature)

5 Use Cases

During the Feasibility phase, Hildebrand and the University of Salford established 15 use cases for the SMIOTS solution based on contributions from external stakeholders in the energy sector (via a survey) and internal energy sector expertise.[32]

As described the previous section, there are three levels of the Glow SAPC solution depending on the hardware requirements and level of complexity, summarised here and reflected in the next section:
Level 1. SAPC + Client device + environmental sensor
Level 2. SAPC + Client device + environmental sensor + LCT (Modbus connection) and
Level 3. SAPC + Client device + environmental sensor + LCT (Modbus connection) + supplier set calendars

Post project completion we plan to run Use Cases Levels 1 & 2As from the list above as part of the Future Homes programme led by the Energy House Labs of the University of Salford. See Future Plans Section.

5.1 Summary of Use cases

ID & Level	Name & Description	SAPC based solution
DS-1 Level 1	**Energy and building internal conditions monitoring** The company intends to develop an automated reporting system for its clients on energy and building internal conditions monitoring for the cases where historical mistakes had been made due to poor metering strategies and lack of data visibility.	Requires access to internal air quality data. SAPC can support this Use Case if the air-quality monitoring system has API capabilities for the Client device to retrieve the data.
DS-2 Level 2	**Dwelling performance monitoring equipment for the Energy Demand Observatory and Laboratory (EDOL) research project** To explain energy use in terms of household activities, building physical characteristics, weather, routines, and living patterns, the EDOL project team needs to collect a large number of high resolution longitudinal social and technical variables related to energy use in buildings (technical data (e.g., disaggregated electricity loads), social data (e.g., household occupancy routines), and contextual data (e.g., local weather)) and at scale (>2,000 homes).	Requires access to the following data: (i) occupancy sensing, (ii) internal environmental characteristics for thermal comfort (e.g., temperature, humidity), (iii) appliances / devices performance and operation (heat pumps, boilers, solar PV, EVs) and (iv) appliance consumption; smart plugs. SAPC can support this Use Case if the occupancy and internal environment monitoring system has API capabilities for the Client device to retrieve the data for (i)&(ii) and if the appliances and devices of interest have the appropriate interfaces in order to be controlled by the Client device either directly or indirectly through the appropriate Gateway for (iii)&(iv).

ID & Level	Name & Description	SAPC based solution
DS-3 Level 1	**Demand side management of energy storage to enable DSR for space heating** A building's potential for demand side management can be estimated by measuring its thermal performance using energy and internal temperature data. A building's potential for demand side management is necessary for specifying the energy storage needs of the building, e.g., if x kWh of energy is needed to cover a 6 hr period, the storage size (battery or thermal store) required to allow response over that time period would be determined.	Requires access to internal temperature data. SAPC can support this Use Case if the internal temperature monitoring system has API capabilities for the Client device to retrieve the data.
DS-5 Level 3	**Smart Local Energy Systems for Oxfordshire** Households will participate in a smart local energy scheme involving smart heating, EVs and smart home products and services.	Requires access to the following data: (i) Space heating, (ii) EV charging and (iii) Smart home products / services. SAPC can support this Use Case if the appliances and devices of interest have the appropriate interfaces in order to be controlled by the Client device either directly or indirectly through an accessible interface.
DS-7 Level 1	**Monitoring of multiple rooms' internal temperature and humidity for assessing the performance of a domestic heating system** Monitoring the temperature and humidity of multiple rooms of a building / household.	Requires accessing internal temperature and humidity data from multiple rooms of a building. SAPC can support this Use Case if the internal temperature and humidity multiple-room monitoring system has API capabilities for the Client device to retrieve the data.
DS-8 Level 1	**Domestic heat and water meter monitoring** Access heat metering and water metering data (potential future application).	Requires accessing space heating and water metering data. SAPC can support this Use Case if the space heating and water metering monitoring system has API capabilities for the Client device to retrieve the data.
DS-9 Level 3	**Night storage heaters** Night storage heaters can be used to shift energy demand for heating to overnight, low cost, electricity. The storage heaters have an energy capacity that is released during the day but also have a boost function to create heat on demand if there is not enough stored energy. Ceramic elements are used to store the energy and will cool to ambient temperature over 12 to 24 hours. Delivery is modulated through a mechanical valve that allows air to flow over these elements and transfer to the surrounding room.	Requires access to the following data: (i) Charge level of the storage heater, energy required to charge-up, running of the heater and programmed schedules, (ii) Internal temperature, (iii) Occupancy sensing. SAPC can support this Use Case if the corresponding sensors have API capabilities for the Client device to retrieve the data for (ii)&(iii) and if the night storage heaters have the appropriate interface in order to be controlled by the Client device either directly or indirectly through an accessible interface for (i).

ID & Level	Name & Description	SAPC based solution
DS-10 Level 2	**Heat pumps** Heat pumps are a way to electrify heating. They are currently used in many commercial buildings and government policy is in place to promote their adoption within domestic environments. Heat pumps heat water and have thermal storage in the form of water to buffer.	Requires access to the following data: (i) Heat output, (ii) Internal temperature, (iii) Occupancy sensing, (iv) Thermal storage capacity and level SAPC can support this Use Case if the corresponding sensors have API capabilities for the Client device to retrieve the data for (i) - (iii) and if the Heat Pump has the appropriate interface in order to be controlled by the Client device either directly or indirectly through an accessible interface for (iv).
DS-11 Level 3	**Home batteries** Home batteries can be used to power the house and shift electricity demand from peak hours. If used in combination with local generation, such as solar, they more efficiently use the electricity rather than putting it back on the grid. They offer total flexibility in their ability to be used at times of peak demand and charge at times of low demand.	Requires access to the following data: (i) Energy capacity / level, (ii) Schedule or rules for charging, (iii) Energy consumed in the home instead of imported from the grid, (iv) Operational parameters (temperature, cycles, etc). SAPC can support this Use Case if the Home Batteries have the appropriate interface in order to be controlled by the Client device either directly or indirectly through an accessible interface.
DS-12	**EV car charging – domestic** EV car charging is necessary with the electrification of transportation. Most homes that have a car will require EV charging infrastructure. New demands will be put on the electricity network.	Requires access to the following data: (i) Energy capacity / level, (ii) Schedule or rules for charging, (iii) Submetering of electricity delivered to EV charge profile, (iv) Operational parameters (temperature, cycles, etc). SAPC can support this Use Case if the EV charger(s) has the appropriate interface in order to be controlled by the Client device either directly or indirectly through an accessible interface.
DS-13 Level 3	**EV car charging - non-domestic** EV car charging is necessary with the electrification of transportation. For non-domestic charging facilities, such as fleet depots, charging bays may be shared or rotated. These facilities may or may not have more aggregated demands on the electricity network. In some cases domestic premises may host a non-domestic EV – i.e. work van for field engineer, which will have some of the issues of DS-12 with additional assumptions.	Requires access to the following data: (i) Vehicle / battery identification, (ii) Energy capacity / level, (iii) Schedule or rules for charging, (iv) Energy delivered to the home (v) Operational parameters (temperature, cycles, etc). SAPC can support this Use Case if the EV chargers have the appropriate interface in order to be controlled by the Client device either directly or indirectly through an accessible interface.

ID & Level	Name & Description	SAPC based solution
DS-14	**EV car charging – public** EV car charging is necessary with the electrification of transportation. Public charge points may be like a fuel station, where consumers are exclusively using charge points to refuel during a journey or as street furniture outside domestic premises where on street parking is a feature of the neighbourhood. On- and off-street car parks will require charging infrastructure that can be used with the consumer's energy requirements communicated and factored into the overall system constraints. These may be a mix of domestic and commercial vehicles.	Requires access to the following data: (i) Energy capacity / level, (ii) Schedule or rules for charging, (iii) Energy delivered into the home, (iv) Operational parameters (temperature, cycles, etc). SAPC can support this Use Case if the EV chargers have the appropriate interface in order to be controlled by the Client device either directly or indirectly through an accessible interface.
DS-15	**Traditional demand side response – DSR** Appliance load shifting through either automation or behaviour can shift small amounts of demand. Signals back to the grid that shifting is happening do not exist currently and likewise there is no demand "intentions" which are sent to the energy network. Demand side response has relied on pricing signals (both fast response and scheduled demand) with little ability to enforce, except through financial penalties or un-earned income. Larger appliances that are used occasionally are the targets of DSR. These things such as electrical cooking, washing, tumble drying, hot water, air conditioning/heating, water pumps, hot tubs/sauna, towel heaters, beauty and haircare.	Requires access to the following data: (i) Device on/off state, (ii) Occupancy sensing, (iii) Thermal capacity/demands, (iv) Runtime schedules and (v) Submetering devices of interest. SAPC can support this Use Case if the corresponding sensors have API capabilities for the Client device to retrieve the data for (ii) and if the appliances of interest have the appropriate interface in order to be controlled by the Client device either directly or indirectly through an accessible interface for (i) and (iii) – (v).

6 Trial phase

This section was written by Utilita for the five sites where the Glow SAPC was installed. Technical findings are summarised in Appendix 2; they will inform ongoing product development.

6.1 Aim of trial

The Trial aim is to test the impact of SAPC technology in domestic properties, with at least one type of low carbon technology in situ.

6.2 Recruitment strategy and onboarding journey

Utilita approached the recruitment of this niche group of customers with caution, considering the limited number of eligible candidates. Given the exceptional support provided by Utilita staff members in previous projects, the first group of customers (Group 1) was prioritised for recruitment into this trial. Group 1 consists of highly engaged professionals with various levels of seniority, who have the industry knowledge that can provide valuable feedback to the trial and de-risk the recruitment process. Based on feedback collected from the first phase of recruitment, Utilita extended the opportunity to a second group of customers (Group 2) to recruit consumers for specific use cases, such as vulnerable households, and fill any remaining slots.

Eligible customer groups	
Utilita Staff Members	Social Housing Tenants
	ECO4 Customers
	ATP Renewables Customers
Group1	**Group2**

Table 1: Groups of Customers for Recruitment

Eligibility was defined based on specific technical criteria around connectivity, meter type (meters had to be SMETS2), and data quality. Eligible customers were initially invited via two waves of email campaigns to join the trial. To replenish the number of triallists, target phone calls were conducted.

Utilita onboarded three properties that have low carbon technologies, supplied by its asset installation arm, Utilita Home. The properties were located in close vicinity to each other to reduce the time between installations. These three sites were complemented by two installations in 'lab type' facilities on live meters (Utilita's Warrington lab where LCTs are tested and the University of Salford Energy House).

The onboarding process included providing detailed information to participants about the trial and obtaining their acceptance of the related Personal Information Notice and Terms & Conditions.

Finally, onboarded triallists were required to register with Hildebrand's Bright App to complete the onboarding process. In the background, Utilita and Hildebrand liaised to set up the triallists on the system.

6.3 Installation considerations

The device has the potential to be a 'plug and play' solution, eliminating the need for an engineer to perform the installation, which significantly impacts the cost-benefit analysis (CBA) due to much lower costs.

Finally, wireless connectivity to low carbon technologies is essential for domestic customers to make the installation less intrusive.

6.4 Initial trial findings

In the trial phase, the device has demonstrated ease of installation. There were a few issues with commissioning the first unit; the second one was commissioned without event.

The encrypted data from the device is currently being decrypted by Utilita's adaptor service.

To achieve its 'plug and play potential' with consumer self-installation the device must meet specific health and safety standards, such as including an insulated special key to activate the commissioning process. An enhanced design of the device can address this and any other concerns.

6.4.1 Findings post installation: DCC standard protocols pose a challenge

A few weeks after successful installation the SAPC devices were reporting a status of 'Decommissioned' on the DCC Inventory. Discussion with Utilita highlighted that there may be a potential industry issue for the SAPC device with the current protocols.

The SAPC must be registered as an ESME; therefore it reports in the DCC Inventory and energy supplier's systems as the same. DCC issue a regular report, which suppliers must act on, when they identify occurrences of multiple commissioned meters to a single MPxN or Comms Hub. The supplier is expected to have only one of said devices registered and the other, 'second' device must be decommissioned.

DCC confirmed that this is the case; typically, it is used to act as a prompt for investigation when a meter may have been physically removed but not yet decommissioned on the DCC system. (Note that Hildebrand see this occur reasonably often in our day-to-day activities). Clearly there are valid scenarios where more than one EMSE will be present and in use (i.e. ESME and SAPC) but the DCC's reporting data can't reliably indicate which meters are physically present and/or which is the boundary meter for the premises which is why they rely on the supplier to investigate and action appropriately.

Clearly this would also be a challenge for a gaining supplier in the event of a Change of Supplier (COS); they won't know which device the SAPC is. As highlighted earlier, there are other expected challenges with SAPC and COS gain due to unfamiliarity, etc.

DCC have started internal discussion on this previously unidentified challenge and would appreciate any insight from DESNZ; for example, would a SAPC ever be the only ESME variant present?

In the meantime, Utilita are developing a 'workaround' to exclude the devices in the field. For the record, Hildebrand's device ID starts with a 70 which has not been seen on any other ESME in the field.

6.4.2 Trialist feedback

Physical installation was expedient. Additional feedback is anticipated as testing continues.

7 Commercialisation and market development

The Glow SAPC has been developed, manufactured and installed in a handful of trial sites: it is technically viable. In this section we consider the commercial model, including commercialisation, offer a Cost Benefit Analysis (CBA) and discuss market development plans.

7.1 Commercial model

7.1.1 Market viability

At the heart of the solution's success is to establish a new product within the energy market. One that provides a common, open and secure information source for load control and export.

Currently, LCT operators such as aggregators and energy suppliers providing flexibility market participation are expected to be the initial buyers with further customer segments expected to evolve with the market itself. They may purchase the product directly or bundle it with the LCT installation or flexibility service. Because of current technical limitations, someone with a Supplier Role within the DCC must install, commission and receive the alert payloads from the Glow SAPC.

To assess market viability, the project's research activity was to:

1. Design a business model outlining the customer segments and operating environment; done in general terms to then test during field trials
2. Determine key customer segments
3. Show the partnerships and supply chain that will need to be in place to create a business model

The following assumptions are made to drive forward a successful commercial model:

1. Consumers will drive the adoption versus an infrastructure driven adoption. Smart meters were a license condition and the whole energy system got behind standardisation and installation. SAPC devices contribute to the capability of the smart meter system, however consumers will have to “buy in” to the SAPC offer.
2. Utility of the device on its own is zero - there are more devices required, to ensure that the proposition does not exist in a vacuum.
3. Most of the benefits are from services that reduce energy bills or create revenue based on energy flows; those services must be considered in line with how the services will best use/exploit the device's capabilities.
4. Technical and security constraints mean that devices can only be operated by certain companies that have specific roles in the DCC, meaning **only** those companies or **partnerships** with those companies are required, currently a Supplier Role is required.
5. It is unclear how the DCC might allow SAPC devices - how much more traffic will be driven and if successful, will the cost of using DCC communications be uncompetitive.

In terms of innovation, there is a “closed” network issue that only certain types of companies can operate services - which limits the types of companies that will be able to utilise the devices in the current SEC framework (see What comes next? section for further discussion).

7.1.2 Competing solutions to the SAPC

The counter to the SAPC device is to install a non-SMETS device on a different network. Ironically, this counter solution becomes more closed as the device's capabilities are based on the device provider's service offering (may be the device manufacturer and/or distributor or third-party service provider) - if the energy consumer wanted to change service offering, they may have to change devices.

Open protocol devices could change this - where more than one service provider could deliver the service if they speak directly to the device, however with some entity having to provide connectivity service (mobile, WiFi, etc) it is unlikely that ubiquitous, secure services could be deployed with interoperability between connectivity service providers – making an open protocol less impactful.

PAS1878 and PAS1879 define standards for appliance control and demand side response. Given these are similar to OpenADR, there may be more autonomy by each appliance manufacturer rather than centralising the device schedules into a coordinating device like the SAPC.

The one thing that these solutions **do not have** is **access** for the **energy supplier** or **grid operator** to be able to **send market signals** as well as **energy network technical constraints**. They are **wholly dependent on** the **communications infrastructure adopted by** the **appliance manufacturer**. In this respect we think there is a **role** for the **SAPC** to play in **price** and **constraint signalling**.

7.1.3 Determining price

Depending on how the device is sold, there could be different pricing models (note: price is distinct from the actual cost of goods presented within the following CBA). Over and above the price of the device itself, there is potentially an installation cost – however, the design of the device means it could be self-installed by a householder as demonstrated during the trial. The new capability that the SAPC devices enable offers direct benefits in lowering energy bills (through efficiency gains or energy market optimisation) or could be 'cash back' to consumers through a more direct flexibility market engagement. There is also an increase in comfort that could be realised if retrofit measures are better targeted and monitored to maintain a warm home.

7.1.4 Methodology

Hildebrand use a framework for developing a commercial business model developed by Strategyzer. Key to the approach is ensure that the business develops a value-based proposition.

The following topics are the key components of the business model.

7.1.5 Stakeholders / customer segments

In addition to the end users of the SAPC, companies in the supply chain might be willing to fund the device and installation costs. Although this is a probable outcome of the final business model, without successful end user propositions, companies in the supply chain will not have a business case to fund.

The end user customer segments have been described as customers that may already be on a journey to adopt an LCT. Some customers may be at different points, for example have an EV and considering a heat pump or in the early stages of considering potential retrofit efficiency measures for their home. While not exhaustive, the following target segments align with larger market trends.

Retrofit - this is a homeowner that may be owner occupier or a social or private landlord. In this context, retrofit is to improve the fabric efficiency. There are wider issues of which entity realises the value of the actual retrofit. SAPC data collection has a functional role to provide targeted information to make cost effective investment decisions and assess efficacy post retrofit activity.

Heat Pump considerers and owners - home owners considering a heat pump are interested in bringing the thermal performance of the house up to levels required to make a heat pump work; owners of heat pumps may initially be interested in measuring coefficients of performance, optimising performance and eventually using the heat pump in flexibility events in future.

EV car owners - there isn't much of a use case to use within SAPC for evaluating the purchase of an EV, it is in-life operation of an EV for flexibility and tariff optimisation where SAPC is relevant; there are some technical capabilities required of the EV or charge point.

Solar Owners - like the EV case, the intelligence in SAPC will be used in efficient operation of solar energy flows and, combined with other LCTs, becomes even more powerful and complex.

Battery Owners - again, using two-way communication and charging schedules, to cost optimise the imported energy to meet expected demands.

Industrial flexibility - this customer segment relies on the control of larger, more complex systems that can be informed by a SAPC device.

Generally, the customers described above have similar situations, so a single customer empathy map (part of the Strategyzer framework) has been generated to capture the dynamics of a typical customer:

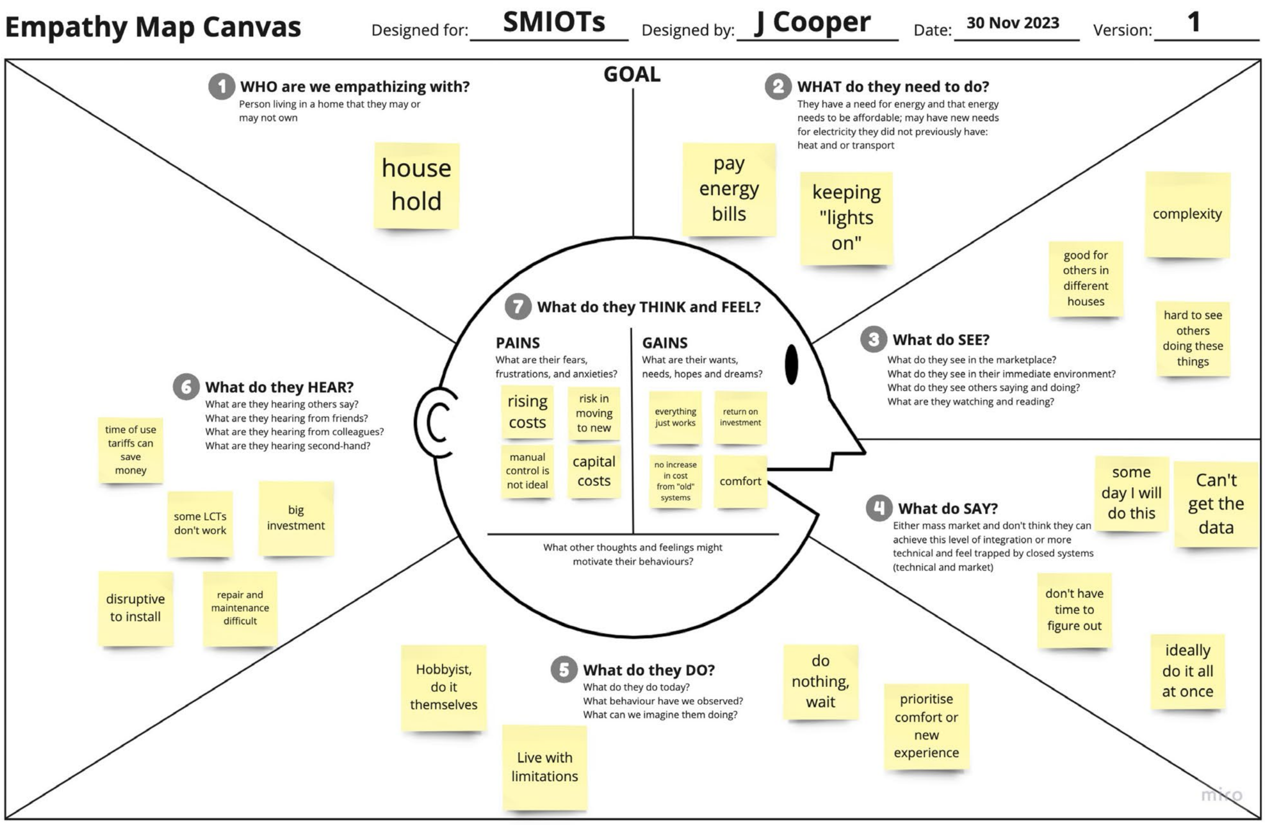

Figure 5. Strategyzer Empathy Map Canvas

7.1.6 Value propositions

7.1.6.1 Definition

A value proposition in marketing is a *concise statement of the benefits that a company is delivering to customers* who buy its products or services[33]. If the value proposition isn't compelling, there is no business to build.

We have focused on the value proposition to the end user consumer of the SAPC system or the related service that will be required.

Flexibility payments – directly linking the use of LCT and the device schedules to payments provided by various flexibility markets. This could be most attractive to households that have purchased their own LCT – for instance EV or battery owners. This could be DFS, local DSR events or other emerging flexibility markets.

Behind the meter payments – this uses the P375 and P415 style market settlement where a meter can be used to settle local energy flows from batteries, solar or other generating assets. Given the feed-in tariff is low for solar and battery, this may be attractive for these consumers.

Bill reduction – mass market adoption will be "full service" energy companies that can reduce household bills through a combination of market mechanisms such as half hourly settlement and flexibility markets. Local energy management will need to maintain comfort level while optimising local energy needs.

House protection – for early adopters of EV, solar and batteries there is a concern about the capacity of supply into the home. Being able to control maximum demand to stay below the limit of the grid connection.

7.1.7 Glow SAPC's potential routes to market

Potential routes to market have been explored but not finalised. The channels that have been shown are:

1) a direct market (early adopters),
2) LCT installers that may fit the device as a part of a larger install and
3) energy services companies (includes retail energy suppliers).

7.1.7.1 Revenue model

The business model takes the value proposition(s) and extends them to address the need to capture revenue. A list of potential revenue streams for the Glow SAPC has been developed:

- Direct sales
- Advisory service
- Technology provider (white label solution)

7.1.7.2 White label or direct to market

Potential business models will be further examined and finalised within Phases 2 & 3 (if the project progresses). Below is the current analysis of offering a white label versus direct to market solution.

Route	Description
White Label Options	• White label: the solution is embedded within another service offering • Own brand: launch as a new device with service offering
Supplier	• Embed the technology into the supplier's offering • Suppliers may want exclusives • Possible lock-in to supplier services
LCT company	• Value added service for the installer • Additional margin for install • Additional service offer for monitoring and maintaining performance
Direct to market Options	• Solution is offered directly to the energy consumer, not via an intermediary
Commercial site	• Need to drive traffic to get visitors • Ability to deliver the services behind the device (flex and lower bills)

7.1.8 Assessing commercial viability

The SMIOTS solution will only work commercially if stakeholders are aware of, and engaged by, the platform. Further exploration will continue into the understanding of a SAPC device for both buyers and sellers – is it understandable to both parties? Will they take the solution up? What is the service offering that must come with the device?

7.1.9 Pragmatic decision making driven by the market

Strategyzer offer another tool called The Innovation Project Scorecard which we use to help keep the team 'honest'. This is important because it can be easy to lose the external perspective when the focus is on developing the solution; the framework will be used to ensure we continue to sanity check development within the context of market viability.

Adaptability		Evidence & confidence					
Industry forces	Our idea/project is well positioned to succeed against established competitors and new emerging players.	0	1	2	3	4	5
Market forces	Our idea/project takes known and emerging market shifts into account.	0	1	2	3	4	5
Key trends	Our idea/project is well positioned to benefit from key technology, regulatory, cultural, and societal trends.	0	1	2	3	4	5
Macroeconomic forces	Our idea/project is adapted to known and emerging macroeconomic and infrastructure trends.	0	1	2	3	4	5

Figure 2. Strategyzer Innovation Project Scorecard

7.1.9.1 Strategyzer's Innovation Project Scorecard explained

Paraphrasing from Strategyzer: "failures happen because companies will focus on their own innovation while ignoring their business environment. Sometimes successful innovations require that companies not only deliver on their promises, but that their key partners also deliver on their promises.

It is possible to design a profitable business model that fails to scale. These constraints on scaling can be the result of limitations in key partners' capabilities, the grabbing of significant market share by competitors or regulatory conditions that are not supportive of the business model.

A big part of designing and de-risking the business model is checking how adaptable it is to its environment. This is why, beyond desirability, feasibility and viability, that concept of adaptability is part of the Innovation Project Scorecard. This allows leaders and teams to track how well their business idea is well positioned to thrive in its environment."

Strategyzer believe that organisations can play a role in (re)designing new business ecosystems to further societal progress which they describe as upruption: "...disruption shifts value around, whereas upruption lifts everyone up and creates a step change of progress." If the Glow SAPC is successful, it has the potential to achieve 'upruption' - in the medium to long term.

7.1.9.2 Industry forces

Generally, there is wide adoption of smart meters and the technical environment exists for deployment of the Glow SAPC. Energy suppliers control the technical installation of the SAPC, and there is some inertia of energy suppliers not providing flexibility services and not eagerly partnering with flexibility service providers. There would need to be some additional incentives developed to get energy suppliers to actively engage in deployment of SAPC. We are **scoring** this at a **2**, which means **the industry would not yet widely support SAPC deployment**.

7.1.9.3 Market forces

There has been some market success with DFS although benefits went largely to the consumer rather than the energy supplier. New flexibility markets are developing and there is a healthy growth of the size and number of events that are occurring. Generally, the market is approachable now. A conservative **score of 3** has been marked, indicating that we are **near wide market support that would enable the SAPC benefits**.

7.1.9.4 Key trends

Trends in the need for a SAPC like device are generally aligned with successful adoption of the SAPC. For instance, cyber security and information needs to operate flexibility are required to be interoperable, portable and ubiquitous. This is **scores a 4** and is **deemed favourable to success**.

7.1.9.5 Macroeconomic forces

Generally, macroeconomic forces are unfavourable in that government, energy suppliers and ordinary people have less real money to spend. It will be difficult to get mass adoption now because of general cost cutting and investment risk. This **scores a 2** – meaning **individuals with money** or **companies bundling the SAPC with higher priced LCTs** will be able to **overcome general economic friction**.

7.1.10 Commercial model conclusion

“There will always be a requirement for energy; the problem is the way it is used, the amount demanded and its contribution to man-made climate change.”[34]

For reasonable market adoption, the Glow SAPC device ultimately needs to deliver lower costs of energy to consumers, with no loss of functional control over their energy. As consumers have more complex energy systems within the home, they can benefit from automation and with standardisation benefit from common expectations. This means people buying LCT assets for the home will not end up technically stranded and be able to share in the ‘wisdom of the masses’.

7.2 Commercialisation

Over and above the commercial model described above, we asked the DCC to provide their perspective on routes to market.

7.2.1 DCC Perspective

The DCC’s engagement with prospective partners in, among others, the health and social care, social housing, local government and retrofit sectors, indicates multiple use cases that would potentially be deliverable through SAPC-based demand. They include:

1. Temperature and humidity data use cases such as enabling accurate retrofit specifications and monitoring in-situ performance, reducing ill-health through identifying households where improvements can be made, supporting Warm Homes on Prescription models through to supporting the deployment of a social tariff; and
2. Unlocking participation in demand side response where there is a need for a managed solution that uses the DCC network.

The organisations that approach DCC are generally interested in some or all of three areas described below, historically there has been limited ability for DCC to support their use cases because there was no suitable technical solution available.

7.2.1.1 Extend data sets beyond smart meter data

The first area is around access to smart meter data to build new propositions or to supplement existing data sets. Generally, the DCC can guide partners on how they can access smart meter data within the current regulatory regime but not go beyond that scope.

7.2.1.2 Use of the DCC network for new purposes

The remaining two areas relate to using the latent functionality inherent within the network and SMETS devices and using the DCC communications network for novel (i.e. non-metering) purposes. On considering these two areas, there are complexities and limitations that historically have often meant organisations look elsewhere for cost effective solutions to support their initiatives. As a direct result of this project, the DCC are now able to point to the Glow SAPC as an example of the network being used to carry non-metering data and of proportional load control via the DCC network becoming a reality.

Below are some examples of the types of projects the DCC have been involved in that are in the public domain, with an indication of the relevance that the technology delivered by the Glow SAPC has for organisations with similar aims:

Project	Context	Relevance of Glow SAPC
Greater London Authority (GLA) Home Response project[35]	The Home Response project explored flexible energy solutions for Londoners and considered the viability of a Smart Meter System based architecture[36]. The project was delivered without any integration with DCC, in part due to the absence of a proven end-to-end solution for load control of low carbon technology assets via the DCC network.	Local Authorities and other social landlords looking to offer flexible energy solutions to their tenants in tandem with the installation of low carbon technologies in their property portfolios can now consider the possibility of deploying SAPC-based solutions to automate demand side response without reliance on tenants' WiFi or on private data communications, noting that there is still a need to partner with an Energy Supplier to offer such solutions.
London Office for Technology and Innovation (LOTI) and the Greater London Authority (GLA) Pan London IoT Damp and Mould Project[37]	LOTI deployed a number of sensors across the London Boroughs on a trial basis. The project demonstrated the value of sensor data for mitigating the health risks associated with damp and mould and highlights the need to be able to acquire that data without reliance on residents' WiFi. The project used a London-wide IoT platform for data acquisition, however the SAPC solution opens up the possibility of using the DCC network for similar applications by local authorities within, and outside of, London. "The London Office of Technology and Innovation is looking forward to discussing the findings of our Internet of Things Sensors for Damp and Mould programme with the DCC to explore whether the use of the DCC's network could help to scale temperature and humidity sensor data acquisition."[38]	SAPC delivers a device capable of collating and forwarding temperature and humidity sensor data via the DCC network, which has the advantage of being highly secure, reliable, ubiquitous and fully funded. As noted elsewhere in this report, the current specifications require that a SAPC must send alerts carrying data payloads to the Energy Supplier. If that remains a constraint, then onwards distribution of that data for these applications would require the cooperation of Energy Suppliers. DCC therefore recommends exploration of other models for distribution sensor data acquired from SAPC devices, including evaluating the technical and regulatory changes that would be required for DCC to fulfil that role – see Section 9.1.
DESNZ's own Smart Meter Enabled Thermal Efficiency Ratings (SMETER) programme[39]	The SMETER programme demonstrated the value of using temperature data alongside smart meter data to calculate buildings' thermal efficiency ratings, which can support building retrofit assessments, performance monitoring and financing. The SMETER projects that deployed temperature sensors relied on WiFi or private data connectivity, and several experienced some problems with data acquisition. At the time the projects were delivered there was no mechanism by which sensor data could be backhauled via the DCC network. As the adoption of SMETER methods becomes more widespread there will be an increased need for temperature sensor data.	SAPC delivers a device capable of collating and forwarding temperature and humidity sensor data via the DCC network, which has the advantage of being highly secure, reliable, ubiquitous and fully funded. As noted elsewhere in this report, the current specifications require that a SAPC must send alerts carrying data payloads to the Energy Supplier. If that remains a constraint, then onwards distribution of that data for these applications would require the cooperation of Energy Suppliers. DCC therefore recommends exploration of other models for distribution sensor data acquired from SAPC devices, including evaluating the technical and regulatory changes that would be required for DCC to fulfil that role – see Section 9.1.

7.3 Additional opportunities for the Glow SAPC

The project has successfully demonstrated how the DCC's existing network can be used to retrieve data from in-property sensors. Use of the DCC network helps overcome issues with data retrieval via other means (for example over the internet) due to its ubiquity, security, reliability and connectivity as core national infrastructure. Potential demand for the functionality is broad ranging, with interest expressed to the DCC by local authorities, social housing providers and technology companies.

Currently the Smart Energy Code (SEC) specifies that the data to and from a SAPC device only goes to the energy supplier; device certificates control data flows and they restrict access to the energy supplier role. This restriction may limit the depth and breadth of market opportunity.

We see value in exploring options to remove the current restriction of data access to the supplier role; a relevant metaphor is the Consumer Access Device (CAD) that is mandated by the SEC to be supported by energy suppliers **and** DCC Other Users. Options and implications for this change to the SEC are discussed in Section 9 and underpin the following cost benefit analysis.

7.4 Cost Benefit Analysis (CBA) - Market wide level

During the Feasibility phase a significant piece of work was developing a CBA for the SAPC based solution. See Appendix 3 for full details.

Phase 2 findings don't significantly affect the CBA that was developed; more broadly, market drivers towards achieving flexibility faster confirm that the value of the solution could be amplified.

Below we provide a synopsis of the CBA at market wide level. The counterfactual was to not put the device into the market.

7.4.1 Analysis of costs

Costs are modelled as initial development cost and then cost to the end user. The market may decide to bundle the SAPC with LCT device(s) or provide it in conjunction with a service (for example, heat as a service for heat pumps).

Potential additional running costs on the DCC network were not considered.

Net present cost[*] for the development activity was calculated to be £8.3m.

Unit cost for the device continues to be £55/unit (could be brought down in future when manufacturing in high volumes).

7.4.2 Analysis of benefits

Analysis of benefits was underpinned by selecting nine priority use cases as outlined below.

[*] Discounted cost of an investment, reflecting the time value of money. Equivalent to a negative net present value (NPV).

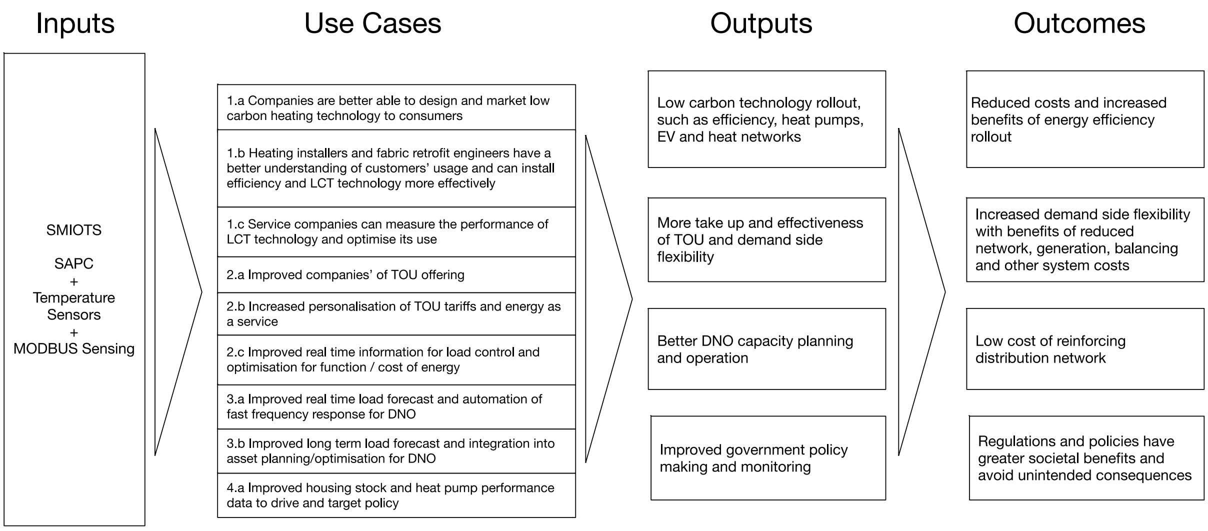

Figure 6. Flow of benefits from implementation of SMIOTS

For each use case a rationale is proposed for why the SAPC may provide benefits over the counterfactual of doing nothing. Note that the CBA is an initial indication of a broad order-of-magnitude estimate; preparing a fuller CBA is an activity that is out of scope of this project but recommended in future.

The level of the ultimate benefits identified (Outcomes column) are summarised below (details in Appendix 3).

7.4.2.1 Reduced costs and increased benefits of technology rollout

SAPC ensures when consumers purchase assets such as heat pumps, insulation, and electric vehicles this is done at the right time and in the right way thus reducing costs and increasing benefits of activities and technologies required to hit net zero. In order to meet the 2050 net zero target, there will need to be 43m energy efficiency installations and 13m heat pump retrofits by 2040, according to the Climate Change Committee (CCC)'s Sixth Carbon Budget[40]. SAPC can help facilitate this process in three ways.

1. Allows companies to better design and market energy efficiency low carbon heating measures to consumers
2. Provide heating installers and retrofit engineers a better understanding of consumers' usage to support more effective insulation and LTC installation
3. Gives service companies the ability to measure LCT performance so that usage can be optimised

7.4.2.2 Quantifying benefits of better targeting of low carbon heating measures

The CCC's Sixth Carbon Budget quantifies the household capital expenditure required to install the energy efficiency and low carbon heating measures required to meet net zero; expenditure of approximately £8.4bn per year is estimated: £2.8bn for energy efficiency measures and £5.6bn for low carbon heating, between 2023 and 2039.

Our modelling assumes that each of these use cases brings about a minor reduction in this capital expenditure in three use cases:

1. Better design and marketing of energy efficiency and LCT reduces costs by 0.1%
2. Professional intervention designers better understanding of current consumption reduces costs by 0.1%
3. Local optimisation due to better understanding of heat demand supports improved planning and operation reduces costs by 0.1%

7.4.2.3 Increased demand side flexibility

Two use cases relate to demand shift through increased take up of ToU tariffs[41]. The SAPC may increase the take-up of ToU tariffs by improving the ability of energy suppliers, LCT suppliers and flexible asset optimisers[42] to target consumers with enhanced ToU tariff offerings, including automation of ToU dispatch based on consumers' usage preferences. SAPC also supports new models for heat, charging and flexibility offerings:

- 'as a service' offerings
- optimisation at a neighbourhood and local level (consumers could publish their capacity and constraints, securely, to others in their local neighbourhood)

7.4.2.4 Quantifying the benefits of demand side flexibility

The 2019 Smart meter CBA quantifies some of the benefits of shifting demand that is enabled by the Smart Meter rollout, and the resultant enabling of Time of Use Tariffs, at £1.4bn[43]. At least in the near-term this may be an underestimate given that energy prices are now expected to be higher than when this forecast was made.

7.4.2.5 Lower network costs

Historical smart meter data allows DNOs to more easily identify areas in the existing network which are at risk and might require reinforcement. For DNOs, half hourly data (as opposed to merely total consumption) is particularly important because they need to understand and forecast peak demand. By being able to better understand if the energy is being stored as heat or electrical energy, when or if that energy may return to the grid and whether there is an efficiency gap in, DNOs will be able to reduce investment costs, leading to an overall societal benefit. The SAPC data streams are at the same level of granularity as smart meter data. DNOs benefit by:

- supporting the ability to aggregate consumers' SAPC data at feeder level with the same dimensions as the smart meter data allowing for a direct comparison of supply, demand and performance,
- allows understanding of how consumption varies by consumer archetype (building type, appliances) in their area; they could use these different archetypes to model future consumption, for example by seeing how a move towards electric vehicles will change the consumption load.

7.4.3 Market wide level CBA summary

Given that the benefits assume a very large percentage of take up by the available market, the best way to compare the costs and benefits is on a unit cost / benefit basis. Enhancing that further, a marginal cost benefit analysis could also be valid.

If the assumption is that 10 million (50% of households) SAPC devices deployed would provide the benefit, there is a total cost of £ 558m for the devices. Breakeven number of devices would be 7.1m or a third of all GB households.

Realistically no one manufacturer would dominate the market, therefore cannot deliver all of the benefits. Using IHD and metering market shares as a guide, there is a range from 5% - 50% of market share by manufacturer.

A range of market share estimates for households that would benefit and will have smart meters is used as the basis of the CBA.

	Devices	Cost	Benefit
5% market share / 30% benefit	950,000	£60m	£119.5m
40% market share / 80% benefit	3,500,000	£192m	£320m

7.5 Building awareness

At this early stage of the product's lifecycle, building awareness through a range of dissemination activities will be our first market engagement.

7.5.1 Hildebrand dissemination plan

Solution overview, simple version: During the project we developed a two-page overview including visuals of data flows to explain the benefits - it gives a useful explanation 'at a glance' of the Glow SAPC solution. See Appendix 4.

White paper: Hildebrand will publish a white paper, with contributions from project partners, outlining the SAPC solution and its potential role in 1) achieving grid stability and 2) utilisation for wider societal benefits such as fuel poverty identification and data-driven policy making.

Social media planning: The social team have developed and started to implement a social plan for dissemination of the project and its outcomes on Hildebrand's LinkedIn. For the full plan, see Appendix 3.

Webinar event: A webinar will be organised to present the SMIOTS project, the Glow SAPC and our findings. Attendees will include contributors to our use cases from Feasibility phase, as well as any relevant external stakeholders including DESNZ, Ofgem, DSOs, Energy Suppliers and Social Housing providers. The intention is to raise awareness, encourage follow-up meetings to discuss potential future applications with the solution as is, and how capture learnings on how it might need to evolve / be extended to meet stakeholders' requirements.

Video demonstration of solution: Hildebrand are developing a video demonstration of the solution, including a description of it works, what it can achieve, a demonstration of the devices installed in a home, and the data being retrieved. The completed video will be disseminated across various social channels and on our web site.

DCC Test Lab: Hildebrand will ask the DCC Test Lab, where we tested the commissioning of the Glow SAPC in their test environment, for their help in organising two workshops to present the solution and the SAPC to DNOs and suppliers.

7.5.2 Utilita dissemination plan

PR campaign: Utilita plan to do a PR campaign on social media showing the journey of the SAPC device in the form of a video diary showing the journey of the SAPC, from production to installation at various test labs, to installation in the first trial home. The aim of the campaign is to emphasise the benefits of open innovation and collaboration between organisations for the good of energy consumers.

7.5.3 DCC Dissemination plan

Demonstration: DCC plans to install the Glow SAPC and Glow Delta devices in its innovation labs in Manchester and London, which are frequently used to showcase innovation activity to visiting senior stakeholders from the public and private sectors.

Support social media campaign: DCC will promote the Utilita social media campaign through its social media accounts to reach as wide an audience as possible.

Utility Week Live: DCC has been allocated a slot on the innovation stage at the UW Live event and will invite a guest speaker from Utilita to participate and showcase the SMIOTS project.

7.5.4 University of Salford dissemination plan

University of Salford's marketing team: Short articles on the University's and School's (School of Science, Engineering & Environment) webpages, posts on the University's LinkedIn and articles at non-university managed media e.g., local newspapers will be published.

Energy House Labs (EHL): Articles on the EHLs website, LinkedIn posts and Newsletter article will be published.

Academic journal: An academic article is currently in preparation focusing on the Use Cases developed during the first phase of SMIOTS. The article will include a Section dedicated to the technical solution; Glow SAPC and Delta in relation to the Use Cases.

White paper with Hildebrand: Smart Meters > Smart Homes lab will contribute to Hildebrand's white paper.

White paper with the DCC: A second white paper will be prepared with the DCC and the SMSH lab on how fuel poor households which have installed LCTs (e.g., social houses with Heat Pumps) will not be excluded from the benefits of the DSR / energy flexibility services.

Awards: SMIOTS will be in the highlighted projects' list of the Energy House Labs when nominated for relevant awards.

7.5.5 IEA Annex 94 – Validation and Verification of In-situ Building Energy Performance Measurement Techniques

IEA Annex 94, currently in progress, is proposed to "provide a network of experts and facilities to study the methods of measuring the Heat Transfer Coefficients of dwellings"[44]. The annex overview states "the most challenging and valuable part of the proposed annex will be the collection of a large dataset across the globe of typical dwellings"; Hildebrand are leading the working group responsible for that activity and plan to include datasets acquired via the SAPC device.

7.5.6 IEA Annex 96 – Grid Integrated Control of Buildings

Ioannis Paraskevas from the University of Salford and Head of the SMSH lab will lead the *Case studies and dissemination* and will contribute to the *Industry roadmap* subtasks of IEA Annex 96 on Grid Integrated Control of Buildings of the International Energy Agency's (IEA), Energy in Buildings and Communities (EBC) Programme[45].

These subtasks are closely related to SMIOTS. As part of their contribution, the SMSH lab plans to share the findings and observations from SMOITS internationally and to understand the differences among the UK and the international markets on energy flexibility.

Understanding the publicly available smart metering infrastructure of other countries, such as the equivalent infrastructure to GB's DCC, could potentially lead to improvements of the Glow SAPC and the Delta, and to adjustments of the product for markets outside the GB should opportunities like this arise. Clearly significant components of the implementation are unique to the GBCS standard, but core functionality could be extended to other markets.

Ioannis's participation in these Subtasks is supported by Joshua Cooper (CEO of Hildebrand) and Robin Seaby (E2E Architect – Technology Innovation, DCC); Robin Seaby has participated in the SMIOTS's II consortium and has an in-depth understanding of the SAPC / Delta product, its features and more importantly, the interoperability, cybersecurity and other important aspects which need to be considered when a device interacts with the DCC infrastructure. Understanding these aspects is crucial as other countries will have an equivalent infrastructure and consequently, the same parameters would need to be considered if a device with similar features will be developed for other countries.

Note: IEA is an intergovernmental organisation and Ioannis's participation has been approved by Dr André Neto-Bradley on behalf of the Department for Energy Security and Net Zero (DESNZ); André is IEA's Executive Director Committee Member.

8 Lessons learned

8.1 Reflections on device development processes

8.1.1 Don't have to be a meter manufacturer to develop a SAPC

Throughout the project, several stakeholders expressed surprise that a company like Hildebrand, with no experience in meter or communications hub manufacturing or certification, would develop a SAPC device. We were asked why we were doing this; there was scepticism that the goal would be achieved.

8.1.2 Development timetable

Our main conclusion on the device development process is that our initial timetable and project plan for developing the world's first SAPC was too ambitious. Innovative, first of their kind type devices are time-intensive for development, particularly bearing in mind the point made above. Developing the firmware for the device and the levels of testing required took longer than anticipated, as did achieving the external certifications required for developing the SAPC.

The development process for the SAPC required achieving ZigBee, DLMS and CPA certifications (described earlier). While Hildebrand have been through the ZigBee certification previously; DLMS and CPA were new. More significant was that none of the entities had certified a SAPC device before. DLMS testing and certification was a particular challenge, there were no test houses in Europe that could support us as they did not know how to support testing for a SAPC device. This was compounded by the DLMS UA launched a new testing tool with a tenfold fee increase in October 2024. This significantly hindered our ability to purchase and complete the testing ourselves. Although workarounds were identified (and took a lot of time that hadn't been planned for), these roadblocks to innovation create a helpful learning for the reality of developing unique new devices and solutions.

8.2 Value of CyTAL and ProtoCrawler tool

The Glow SAPC is the first time Hildebrand have taken a device through full CPA. CyTAL's ProtoCrawler tool means that when the unit is submitted to NCSC for certification, we will have high confidence that all firmware related functionality should pass. The tool allows the firmware developer to process their code and assess outputs in real-time; other test houses take a very different approach whereby the device is submitted to NCSC, comments come back on firmware, changes are made, device is submitted again, etc. until it passes. The ProtoCrawler license gave the developer confidence in their code.

8.3 Local manufacturing

As mentioned previously, Hildebrand worked with Arista Electronic Systems, a manufacturing company located in High Wycombe, UK, for the hardware development and manufacturing for the Glow SAPC.

Using Arista for the hardware manufacturing component of SMIOTS was a valuable decision. As well as a preexisting and positive working relationship with the company and familiarity with the team, they are experienced with understanding secure manufacturing protocols as required for a Type 1 device.

Working with Arista also demonstrated the value of working with a local manufacturer. Our proximity to Arista allowed for quick turnarounds in production and meant we could do short test production runs, test and learn. For CPA CyTAL will audit the manufacturing process for the SAPC; having a local manufacturer cuts down on the time and effort required to complete that process – CyTAL, were pleased to hear they would not need to travel to the Far East to complete that element of the audit.

8.4 Establishing a market

There is no pre-existing market for a SAPC device in the GB market; Hildebrand's next task is to establish whether that market will exist. Dissemination activity from both Hildebrand and project partners will help build the narrative and raise awareness for the new device and the SMIOTS solution – see the previous section for details.

9 What comes next?

In this section, we present the short- and medium-term plans for the Glow SAPC. We also raise broader topics for consideration now that a device originally described in the Smart Energy Code in 2013 exists; what role might it play in supporting flexibility ambitions and what regulatory changes could be required to facilitate achieving those ambitions with a SAPC device.

9.1 Ongoing and short-term plans

The following activities are currently ongoing or planned for kick off in Spring 2025.

9.1.1 Future Homes programme

The Glow SAPC device will be further tested in the Salford Smart Home of the Smart Meters > Smart Homes (SMSH) lab as part of the Future Homes Innovate UK programme. Hildebrand Technologies and the Energy House Labs have already agreed this project.

9.1.2 Explore DNO led research projects

DNOs are currently extremely active in the flexibility space; discussions indicate that the Glow SAPC solution could deliver the data and insight required to expedite learnings about the property, flexibility technologies and optimising control. The plan is to engage with DNO's, Innovate UK and consultancies who regularly work on Strategic Innovation Fund[46] projects; the Glow SAPC seems to be a natural fit for that innovation funding stream that could support a field trial project of hundreds of properties.

9.1.3 Explore previously identified innovation projects.

Section 7.2.1.2 outlined three previous projects that could benefit from the SAPC solution - planning is underway to explore integrating with these initiatives to enhance their outputs. Potential involvement here will also contribute to market development for the SAPC.

9.2 Medium-long term plans: Stakeholder engagement and standardisation

In addition to the activities described in the previous dissemination section, project findings will inform ongoing engagement with stakeholders engaged in setting flexibility standards.

9.2.1 Contribution to PAS1878

The SMIOTS team (Hildebrand Technology, the Smart DCC, Utilita, SMSH lab / University of Salford) will aim to contribute in the updated version of PAS1878 providing details on the role of the SAPC as a Customer Energy Manager (CEM) for energy flexibility, its capability to operate as part of the DCC infrastructure or through WiFi, its integration capabilities with the household's LCTs as well as with open-source software for Home Automation (such as Home Assistant). **Note**: PAS1878 will be publicly consulted on in summer 2025.

9.2.2 Interaction and collaboration with DEZNA and BEAMA

Hildebrand will continue to share ongoing learnings and developments with the DESNZ team that ran the SMIOTS project. They and Salford are able to help facilitate ongoing learnings between DESNZ and relevant bodies such as the British Electrotechnical and Allied Manufacturers' Association (BEAMA) to discuss the need for protocol standardisation for communications and control of certain Energy Smart Appliances (ESAs) such as: Heat Pumps, home batteries, EV chargers which play an important role in energy flexibility.

9.3 Potential SMIOTS follow-up projects

Listed below are potential follow-up projects that could be pursued now that the technical viability of the SAPC has been proven. All require new funding and sources of that funding are being explored and include Innovate Smart Grants (when they re-open), SIF, the UK Energy Research Centre.[47]

9.3.1 Field trial – Glow SAPC for heat pump control *(funding required)*

A limited field trial focusing on the utilisation of the SAPC for controlling Heat Pumps of social houses, preferably of the same archetype. The aim of the project would be to investigate the effect of load shifting for the DSO as well as the implications to the households. This field trial project could run in collaboration with a DSO, a Social Housing provider and an academic institute.

9.3.2 Field trial – fuel poverty and DSR exclusion *(funding required)*

A limited field trial focusing on fuel poverty and DSR exclusion. This field trial could run in collaboration with a Local Authority, a Social Housing provider and an academic institute.

9.3.3 Develop a dataset *(funding required)*

The objective would be to develop a SAPC dataset from the field trials outlined above and relate it to other existing datasets to bring together internal temperature and humidity data from the SAPC, energy consumption and EPCs. This would aim to provide (i) fuel poverty identification through relating the abovementioned datasets and (ii) use of the HTC as an EPC alternative. The development of this dataset would require a joint initiative with the Dept. for Business & Trade / Open Datasets and DESNZ. **Note**: objective (ii) is similar to the SMETER project but in this case data retrieval would be through the DCC infrastructure with its benefits and not rely on local WiFi. Hildebrand participated in SMETER and a project finding was the lack of reliable local WiFi meant we had to build and install local connectivity alternatives.

9.3.4 Determine CBA of changing current SAPC limitations (Scenarios 2, 3, 4) *(funding required)*

As outlined in the following scenario planning section, the only scenario under which the SMIOTS solution and a SAPC device specifically can function currently is Scenario 1: the energy supplier is the sole receiver of sensor data and the only entity with the ability to set schedules on the device to exert load control. Scenarios 2, 3 and 4 outline additional scenarios that support a more open market for a SAPC device and more choice for energy consumers, but they will require changes to be made to the existing smart metering regulatory framework before they could be implemented. For this reason, our recommended next steps in relation to SMIOTS include determining a cost benefit analysis of implementing the anticipated use cases and related scenarios.

9.4 Potential changes to the smart metering system’s regulatory framework

In the existing smart metering infrastructure and regulatory framework, sensor data retrieved by a SAPC can **only** be retrieved by a supplier. Based on the current rate of progress around SEC modifications and new device types, we are years away from required changes being made to the existing system and infrastructure to allow for alternative scenarios. Table 1 below outlines potential scenarios for the SAPC solution; Scenario 1 outlines the current scenario that requires no changes to the SEC or infrastructure. The remaining Scenarios require change to the Smart Energy Code.

Scenario 2 outlines a suggested change to consider enabling the Load Controller role to provide a channel via which a suitably qualified (existing or new) DCC User role that isn’t the registered Import Supplier for the premises may utilise SAPC load control functionality. This opens a channel for DSR service providers to make use of a national asset to provide services independently of the Supplier, promoting interoperability.

Other factors to be considered include, who commissions the SAPC in options 2-4? Changing commissioning and configuration could be a more fundamental change to the SMIP operating model. DSR service providers would also need access to data that links a specific LCT to a specific SAPC device (in the same way that a Type 2 device installer does for a CAD today). Finally, the criteria for what role in the smart metering system can act as Load Controller (e.g. licensing/ registration) has yet to be defined.

No.	Description	Implications	Strengths	Limitations	Requirements for implementation
1	Supplier Scenario	Sensor data is retrieved by suppliers, suppliers exert load control.	Requires no changes to existing infrastructure.	Minimal flexibility around data access as it would be tied to a supplier – difficult for consumers to change supplier once locked into a supply contract and load control service.	None – current state of the smart metering infrastructure.
2	Load Controller Scenario	A new Load Controller Role would be created to allow an entity access to and control over load control via the SAPC.	Reduces reliance on suppliers, which promotes flexibility within the sector.	Requires a SecMod and DCC to implement.	DCC to implement. **Note**: Scenario exists in the specifications, but DCC has not implemented it; a SecMod would be required.
3	Other User Scenario	The Other User Role could be expanded to allow OUs to access sensor data and exert load control.	Reduces reliance on suppliers, which promotes flexibility within the sector.	Requires significant changes to the SEC.	Regulatory change required to deliver this scenario.
4	DCC Scenario	Sensor data retrieved via the SAPC would be sent to and distributed by the DCC.	Provides flexibility in how sensor data can be accessed, not tied to a supplier or specific users.	Requires changes made to the DCC's systems and specifications.	Regulatory change required to deliver this scenario.

Table 2. Scenario planning for the Glow SAPC

9.5 Regulatory implications

Under current regulations, as described above (Scenario 1), the SMIOTS solution can be implemented for energy suppliers to retrieve data. Suppliers can also use the solution to set schedules to exert load control. However, data access is restricted to the supplier and thus locks the energy consumer into supply contracts and load control services and makes considering Change of Supplier more complex as the gaining supplier may not know how to manage a SAPC device. (**Note**: Change of Supplier will be an issue with early installations as the gaining supplier is unlikely to be familiar with device operation.)

Extending the solution to be accessed by other roles (pre-existing ones such as DCC Other Users, as well as the proposed new Load Controller Role) as outlined in the Scenarios above would extend flexibility and interoperability. Implementing these scenarios would require either regulatory changes or modifications to the SEC (SecMods).

9.6 Policy implications

There are potential policy implications that the project puts forward:

- Extend the current SAPC restriction of data retrieval beyond Energy Suppliers to other SEC trusted and approved entities with a role in the flexibility markets and beyond. An example of 'beyond' is using the data to support better identification of households in fuel poverty.
- Use the SAPC / HEMS combination to inform SMETERS related functionality.
- Require low carbon technology manufacturers to use open protocols for data sharing.

Please see Appendix 6 for a rich overview, prepared by the DCC team, that reflects a number of current initiatives they are involved in with and their view on the implications for the SMIOTS / SAPC solution. These may have policy implications.

9.7 Key use cases in scope

Changes to the current system are **not required** to implement the following important use cases.

9.7.1 Implications for flexibility

The SAPC solution reduces sole reliance on the LCT suppliers to provide data access to the consumer and could de-risk scenarios where LCT suppliers go out of business and data access risks disappearing (which has been seen in the market). The SAPC's new route to accessing data from sensors and smart devices in the home, provides security for the user by acting as a backstop for existing, LCT supplier specific, monitoring systems.

As mentioned above, if additional scenarios are supported, there could be substantial implications for flexibility as new channels open for DSR service providers to provide service independent of suppliers.

9.7.2 Support for vulnerable and implications for fuel poverty

The SAPC solution has the potential to support vulnerable consumers by providing a way for suppliers to monitor temperature and humidity in homes. Internal conditions (temperature and humidity) data when combined with demographics data may form an indicator for identifying fuel poor households. This data-driven indicator can be combined with other fuel poverty indicators, such as the ones used by EU, to have a more comprehensive understanding of a household's needs and the appropriate means for supporting them as fuel poverty has multiple dimensions.[48] Suppliers working with local authorities and social housing providers are expected to see advantages in the solution, particularly as it **does not rely** on **local WiFi** being available.

The SAPC solution could also help address the potential risk of excluding the vulnerable and fuel-poor consumers from flexibility markets and DFS. In cases where consumers have LCTs installed in their homes by a housing association or local authority and may not know how to control or optimise them, the ability for suppliers (or Other Users, should the regulatory framework change) to do so on their behalf via the SAPC would be key for fuel-poor consumers in particular. (**Important**: consumer consent would always have to be obtained before this data, as with smart meter data, was shared with the supplier or any other third party).

10 Conclusion

DESNZ defined targeted benefits and outcomes for the project in their original specification:

Benefits:

- An alternative route for monitoring via an already ubiquitous platform with universal interoperability;
- Consumer independent connectivity (no reliance on consumer broadband etc);
- Minimal additional cost; cost savings compared with alternatives; and
- Easy integration with smart meter energy data.

Outcomes:

- Accelerated commercialisation (of SMS-based IoT-related DSR products and services), leading to:
- Increased system flexibility; and
- Increased uptake of low carbon solutions

Competition objectives were defined by DESNZ and met by the project as follows within our area of interest, energy management:

DESNZ objective	Predicted status, for end of project when Feasibility concluded	Actual status, end of project
Evaluate potential use of the Smart Metering System (SMS) network as a route for monitoring sensors in application areas such as smart buildings, industrial processes and Distribution Network Operator (DNO) infrastructure assets (e.g. Low Voltage substations);	The SAPC device can be used as a general purpose Modbus data acquisition device, we believe it would be able to use outputs from data loggers, industrial devices to communicate data from the distribution network. A communications hub would need to be in place. We have relationships with DNOS that would assist in the evaluation as to the suitability and feasibility.	Could be delivered; requires engaging with DNO(s) to explore interest.
Develop a proven solution for sensor devices (and any required data management tools) that users can manage via the SMS network;	The SAPC device can be fully managed via the SMS. A DCC adaptor, either Supplier, DNO or Other User role would be required to receive alerts. We would open source the sensor decoders so that other DCC adaptors could utilise the data from the alerts.	Complete; demonstrated that the alert functionality delivers the sensor data.
Create a pre-commercial reference design for such devices and supporting systems that may be further developed for full commercial development;	Complete and beyond; full production unit delivered.	Complete and beyond; full production unit delivered.
Identify the specific benefits and challenges of using the SMS DCC network for these applications; and	We highlighted the challenges in PPMID data management and shown that the SAPC device could be used by a Supplier or Other User role in the DCC. Through the demonstration of the device, particular management and operational constraints would be shown.	

DESNZ objective	Predicted status, for end of project when Feasibility concluded	Actual status, end of project
Identify any technical and regulatory changes that may be required for suggested improvements.	None are required.	No changes are required to the existing infrastructure for Scenario 1 (Table 1) and the primary use case for the project. Further scenarios described in previous section changes required to deliver them.

Table 3. Progress made towards initial DESNZ project objectives

10.1 Demonstrated

The project has delivered the Glow SAPC that has been installed in live homes and demonstrates:

- Retrieving sensor data from the home using the DCC infrastructure - a first - adds value to investment
- The DCC infrastructure bring the benefit of
  - being secure and private with no dependency on local WiFi
  - national infrastructure and therefore requires no reliance on third party service providers (as is the case with LCT data today)

10.2 Responses to three challenges posed by the market

During the project some energy sector stakeholders have expressed concerns in relation to the viability of the SAPC as an integrated part of the GB smart metering system. These concerns are summarised below alongside our response, now that the Glow SAPC device has been developed and tested:

1) **The network latency of the DCC platform makes this platform less well-suited for providing a real-time response capability**
   Response
   DSR events are generally known well in advance (weather prediction, DNOs predictive models for consumption etc.) thus, network latency may not be a problem. An energy management / calendar schedule / changes state may be prepared and uploaded to the SAPC in good time.

2) **Incompatibility of current device specifications (commands/ responses) with OpenADR** (expected to be the interface specification for DSR service providers)
   Response
   Government policy could mandate that all LCT devices include Modbus in the UK market to overcome incompatibility issues.

3) **Lack of confidence in the availability and viability of SAPC devices**
   Response
   No longer relevant; the SAPC has now been developed, certified, tested and demonstrated in live environment.

We conclude this report with a thank you to DESNZ and the NZIP funding stream for supporting our development of the Glow SAPC and we look forward to exploring how this world-first device will help drive flexibility and contribute to further innovation in the energy market.

Appendix 1 Glow SAPC Manufacturing

Appx 1.1 Housing schematic

This is the original schematic for the Glow SAPC housing design.

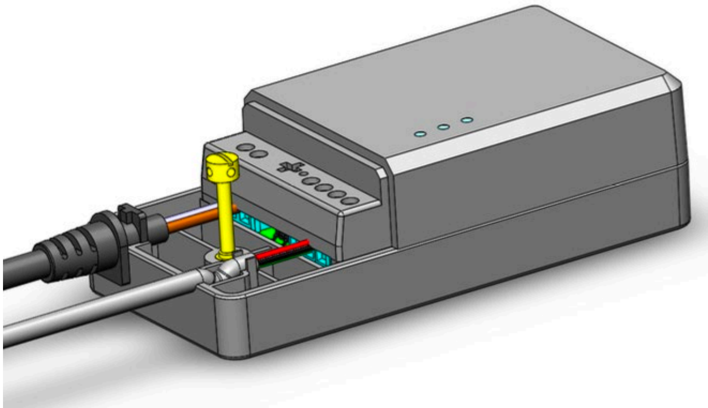

Figure 7. Schematic of housing for Glow SAPC

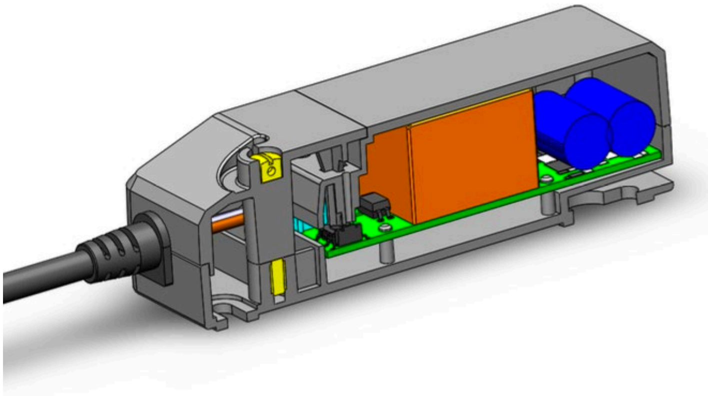

Figure 8. Housing schematic for the Glow SAPC, showing how the board sits within the device

Appx 1.2 Plastics

This image shows the plastics for the Glow SAPC, with the board inserted. The front cover is removed, showing the terminal underneath. The top cover is sonically welded on and cannot be removed, protecting the board.

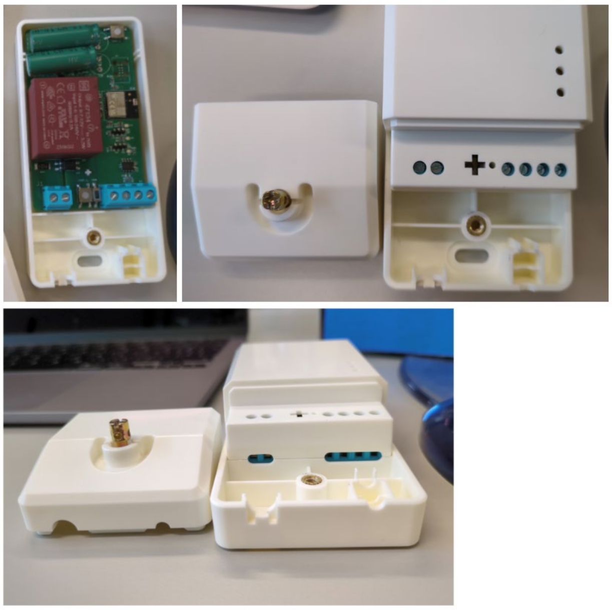

Figure 9. Housing for the Glow SAPC

Appx 1.3 Final versions of the SAPC

Final version of the SAPC – sonically welded with cable attached, and laser etched symbols and identifiers on the device.

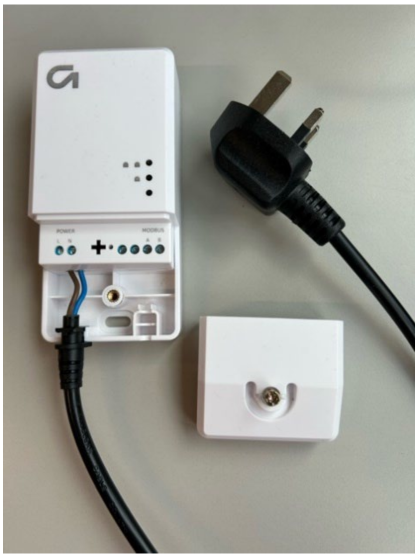

Figure 10. Fully assembled Glow SAPC, front cover removed

Figure 11. Fully assembled Glow SAPC, front cover attached.

Appendix 2 Trial findings: Technical learnings

Hildebrand identified a set of learnings from these first installations which we summarise here:

Appx 1.4 Design

Modbus as a data protocol. There are challenges for installers of the SAPC to understand Modbus and how the SAPC fits into a Modbus architecture. Although this can be overcome with education, it seems that more training and examples need to be provided such that installers and funders can understand how Modbus operates. This is a general shortcoming in the industry and age-old problem of integration. We would not change our approach as we have a high degree of confidence that Modbus will be the predominate protocol for LCTs.

Build a temperature sensor in the SAPC directly. Although we support temperature readings from other devices, it is something that is low cost and would have standalone value. We have actioned this as a part of the final SAPC design.

Build in more space for cables and/or plug in terminal blocks. External peripherals could be plugged directly into the SAPC such as CAD taking power from the SAPC.

Appx 1.5 Differences in DCC Boxed and UIT

The UIT environment required support from DCC and subcontractors in order to get key material loaded into environments and use of the CGI adaptor for commissioning of the SAPC.

Some messages were presented from the UIT environment that required a calculated message authentication code (MAC) and other messages did not. DCC Boxed only presented message requests that required a MAC.

Generally, we found DCC Boxed as a good tool for development. The DCC Boxed development team has noted our findings and will put them into notes and material for other companies that would progress from Boxed to UIT.

Appx 1.6 Differences in UIT and Live

The Live environment depended a lot on the adaptor that was being used and the operational practices of the installing Supplier.

Appx 1.7 Live Operation

Although we need to provide a secure input/output boundary for the SAPC and have mechanisms for tamper evidence, there are challenges in securing the wiring into the device. Only 3mm cabling fits neatly into the data cable port whereas CAT5/6 cables are larger in diameter.

Pressing the JOIN button on the device was needed in some instances. This can only really be done by someone that understands electrical safety as the button is under the terminal cover. We did expose JOIN window functions via Modbus, so it is possible to remotely set the SAPC into JOIN or UNJOIN mode via Modbus.

Appendix 3 Cost benefit analysis

The planned option (SAPC device) will be used in the cost benefit analysis as the counter factual of either "do nothing" or use an alternative technology approach do not deliver the benefits. Specifically, if 3rd party temperature and humidity sensors were used, with WiFi or private data communications, the administrative costs and inconsistency of service challenges would exceed the benefits.

The benefits section shows how the selected option provides unique benefits that alternatives could not.

The SAPC device was selected as the option as the PPMID route would not be feasible within the industry timelines of investment. The majority of PPMIDs have already been purchased and deployed, it is estimated that there are only 2-4 million PPMID devices remaining to be deployed. There was very little appetite for replacing existing PPMIDs to include temperature and humidity sensing. Whereas SAPC is a new market, targeting the homes that would be able to utilise flexibility services, with the SAPC providing an increase in overall utility beyond SMIOT.

Below there is an outline of the costs for development and unit costs followed by an analysis of benefits and a summary.

10.3 Analysis of costs

The costs of a SAPC device can modelled as development costs and then cost to the end user. In some cases, the device would be bundled with LCT technology or be provided with a service. There may be additional running costs of the SAPC device on the DCC network, however these will not be considered for this analysis.

10.3.1 Development costs

The development costs are mainly in the device creation and certification (CPA) and assurance. These are estimated at with the following breakdown:

Development (Fixed costs)	NPV
Electronics design	£0.5m
SAPC host processor firmware	£3.0m
Zigbee firmware	£3.0m
UKCA and EMC testing	£ 0.5m
Zigbee compliance testing	£ 0.5m
CPA certification	£ 0.8m
Overall net present cost	**£8.3m**

10.3.2 Device costs

The unit costs of the devices would be based on volume, for this purpose estimates of manufacturing quantity would be approximately 100,000 units.

The device cost is variable in that it is incurred with the deployment of a device. An average NPV unit cost is assumed over the period.

Device unit costs (variable costs)	NPV
Unit costs	£ 55.00

10.4 Analysis of benefits

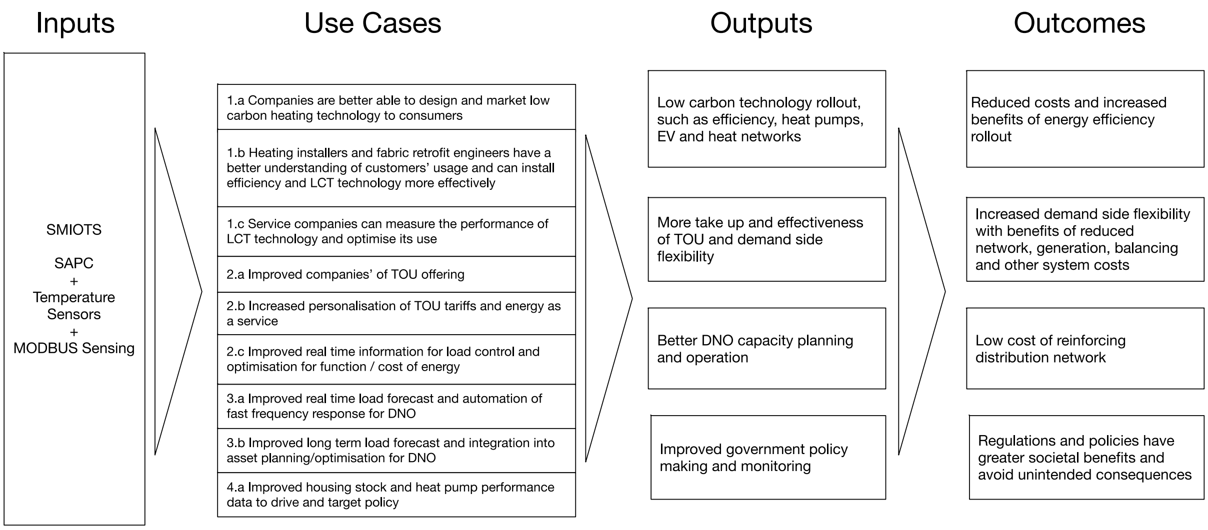

Figure 12. Flow of benefits from implementation of SMIOTS

For each use case, below we set out the rationale for why SMIOT may provide benefits over the counterfactual. A basic quantification is then provided of each benefit. As noted in the introduction, this is an initial CBA, and these qualifications are intended to provide a broad order-of-magnitude estimate. An estimate has been made at the level of the ultimate benefits, which relate to the outcomes described in Figure 1:

- **Reduced costs and increased benefits of technology rollout** – ensuring that when consumers purchase assets such as heat pumps, insulation, and electric vehicles this is done at the right time and in the right way.
- **Increased demand-side flexibility** – enabling consumers to use electricity when it is least costly or the system.
- **Lower distribution network costs –** reducing the cost to DNOs of building and maintaining electricity networks.
- **Improved regulation and policies** – using data to better design and target interventions.

10.4.1 Reduced costs and increased benefits of technology rollout

The first three use cases relate to reduced costs, and increased benefits of the rollout of technologies required to hit net zero, due to better targeting of these measures. In order to meet the 2050 net zero target, there will need to be 43m energy efficiency installations and 13m heat pump retrofits by 2040, according to the Climate Change Committee (CCC)'s sixth carbon budget.[†] SMIOTS can help facilitate this process in three ways.

10.4.1.1 Use case 1.a: Companies are better able to design and market energy efficiency and low carbon heating measures to consumers

The first use case concerns a general understanding of consumers and their needs which companies can gain using SMIOT data to generate better building models, including the use of smart heat transfer co-efficient, measured building and vehicle performance. Through greater understanding of changes to energy usage, based on installations of different kinds of heating measures, companies can better understand consumer needs. This will allow them to design better products, as well as to market them more effectively to consumers.

In the counterfactual, companies will have some useful information, to be able to design and market these products:

[†] https://www.theccc.org.uk/publication/sixth-carbon-budget/

- There is already an understanding of the theoretical reduction in total energy and heat consumption as a result of these installations, especially at an overall level.
- Some granular data would be available, for example from manufacturer collected data if optional telemetry is installed on heat pump or EV.

However, SMIOT would provide understanding of true (as opposed to theoretical) energy consumption, therefore LCT performance and how it varies depending on location, building type and other factors, in a more consistent and granular way than these other sources of information.

10.4.1.2 Use case 1.b: Heating installers and fabric retrofit engineers have a better understanding of customers' usage and can install efficiency and LCT technology more effectively

SMIOT data would also allow individual consumers to receive better advice when installing energy efficiency and low carbon heating measures, by sharing it with the engineers and tradespeople who are retrofitting their property. This would give the tradesperson a bespoke understanding of the consumer's property, allowing them to plan and install the retrofit more effectively, potentially both reducing its costs, and increasing its benefits.

In the counterfactual, consumers might be able to provide this data by downloading it from devices that they purchase on their own. However, SMIOTS would provide the following advantages over this process:

- It would reduce the hassle for the consumer. Instead of having to request the data and then send on to the tradesperson, they could simply give their consent and allow the tradesperson to download it from DCC data flows (Supplier or Other User database). For consumers who are less tech savvy, the difficulty of downloading their data may prevent them from doing this altogether.
- SMIOTS contains more specific and timely data, matching with local weather conditions, and integrated with SMETERs style HTC calculations as opposed to manually having to upload either energy or temperature data the period held by a supplier (which may be very limited if the consumer recently switched).
- The data would be in a consistent format each time, meaning it is easy for a tradesperson/engineer, who is serving multiple consumers. The process for downloading data is currently inconsistent depending on the consumer's supplier and LTC manufacturer and sometimes may be difficult to do.

Taken together, this would mean that smart meter and IOT data is more likely to be available to professionals in the factual than the counterfactual and potentially be more useful when specifying a design.

10.4.1.3 Use case 1.c: Service companies can measure the performance of LCT technology and optimise its use

Real time smart meter data combined with other IOT sensing would also be useful to experts in understanding, operating and forecasting the demand for both energy and heat. This would help them to develop optimisation plans, energy storage, and new complimentary energy devices, to deliver more efficiency in demand and supply.

In the counterfactual, this would be harder to do. No consistent dataset or home energy management platform exists. There are platforms like Home Assistant / Open Energi that may provide some understanding of consumers, but consistency and access to smart meter data is not always available, and the user base in any one local area would likely be low. Local authorities for system wide efficiencies would likely be able to estimate needs based on population density, and building type, but this would not be as accurate.

10.4.2 Quantifying benefits of better targeting of low carbon heating measures

The CCC's Sixth Carbon Budget quantifies the household capital expenditure required to install the energy efficiency and low carbon heating measures required to meet net zero. In total, this analysis anticipates expenditure of around £8.4bn per year, consisting of £2.8bn for energy efficiency measures and £5.6bn for low carbon heating, between 2023 and 2039.

Our modelling assumes that each of these use cases brings about a minor reduction in this capital expenditure. This might result, for example, from being able to more accurately determine the optimal insulation measures for a particular property, or size a heat network or heat pump to meet expected demand. The use cases might also allow the same assets to be used more efficiently (reducing operating costs) but we do not quantify this.

- Use case 1.a: We assume that the impact of better design and marketing of energy efficiency and low carbon technologies, would reduce these costs by 0.1%. This cost reduction would have a net present value of £101m.
- Use case 1.b: We assume that engineers/tradespeople being able to design measures using a bespoke understanding of consumer's energy consumption would reduce costs by 0.1%. The impact on individuals who use this option would be significantly higher. However, we expect such a small impact because we believe a large number of households might do this in the counterfactual by downloading data from their supplier. This cost reduction would have a net present value of £101m.
- Use case 1.c: Finally, we assume that the benefit of local optimisation would make up another 0.1% cost reduction, due to better understanding of heat demand in planning and operation. This cost reduction would have a net present value of £101m.

10.4.3 Increased demand side flexibility

The second two use cases relate to demand shifting resulting from a greater take up of Time of Use (ToU) tariffs.[‡] Such tariffs incentivise consumers to consume energy at times where costs are lower. As described in the 2019 Smart Metering Cost Benefit Analysis, there are many benefits from consumers switching their consumption patterns, including:

- Reducing the peak level of energy requirements, which will reduce the requirement for investment in energy generation, as well as reducing the need for transmission and distribution network reinforcement; and
- lower overall cost of energy (including the cost of carbon), because energy is consumed during a time of day in which energy costs are lower.

SMIOTS may increase the take up of Time of Use tariffs both by improving companies' ability to target consumers with improved ToU tariff offerings, and by allowing automation of TOU dispatch based on consumers' usage preferences. We now describe each of these in turn.

10.4.3.1 Use case 2.a: Improving companies' ToU offering

SMIOTS would allow companies to implement more dynamic TOU of consumers' consumption habits by observing and reacting to usage patterns in an automated way. Both the temperature and storage capacity data that SMIOTS can carry would allow companies to target how energy use is dispatched based on building type, location and any appliances that consumers have. Hence access to this data would make analysis more granular, and through the SAPC device (as it has control) the ability of to automate consumer's demand to shift their consumption.

In the counterfactual, ToU tariffs will still be offered, but may be more limited:

- ToU tariffs can be made to be cost reflective even without analysis of smart meter and IOT data, by directly passing through wholesale price costs (as well as any other costs and revenues that vary, such as opportunities from ancillary service products like DNO constraint payments). However, consumers may be less attracted to a 'bare' ToU tariff than a more tailored product, and cost data would also provide no means of tailoring products to more specific groups (e.g. based on the usage of heat pumps and EVs).

[‡] Tariffs where the rate paid for electricity varies based on the time in which it is consumed. ToU tariffs can be static (like Economy 7, where the time bands and associated prices are announced well in advance) or dynamic (where the prices can change with less notice).

- Energy suppliers will not already have access to the state of EV, heat storage of their own consumers' data, therefore unable to plan and understand heat as a service or different tariffs for different appliances
- Other entities, such as aggregators and Virtual Lead Parties (VLPs)§ would be able to use their technology for submetering and IOT data capture, although as described above, this has a far smaller sample size and not allow for interoperability between VLP suppliers, creating lock in for consumers

Currently, most manufactures of LCT are likely to have access to sufficient data that SMIOTS would not provide a significant improvement. However, SMIOTS may permit a wider range of entities (whether smaller suppliers, or entrants such as heat as a service, technology companies, and charge point manufacturers, which will not have access to a large bank of smart meter data) to understand consumers' needs and offer innovative tariffs.

10.4.3.2 Use case 2.b: Increased personalisation of TOU tariffs and energy as a service

SMIOTS would allow heat/charging/flexibility as a service to offer consumers performance-based tariffs, tailoring the cost/rewards based on the consumer's consumption. This would require consumers to give their consent to the data (energy and IOT) to use it for that purpose, who would then be able to link directly to the SMIOTS and smart energy databases. The advantage of this will be that the consumer can get a consistent offer from service providers. This would make consumers more likely to take up such services.

In the counterfactual, Suppliers already have the option publishing through currently existing platforms, such as Uswitch. However, there are limitations associated with this compared with what SMIOTS might offer:

- A service such as Uswitch can only provide energy data. For example, a Uswitch could use IOT data to indicate a TOU matched to performance related data of LCT or building.
- IOT data is required to understand if the function that the energy is supplying is being delivered – i.e. increased heat, sufficient capacity of battery, this would create new pay for performance products

10.4.3.3 Use case 2.c: Improved real time information for load control and optimisation for function / cost of energy

SMIOTS would allow heat/charging/flexibility to be optimised at a neighbourhood and local level, consumers could publish their capacity and constraints, securely to others, knowing that only their neighbourhood would have visibility into their demand.

In the counterfactual, Consumers would have to make their performance data publicly available. This would pose security and trust risks and would therefore be impractical.

10.4.4 Quantifying the benefits of demand side flexibility

The 2019 Smart meter CBA quantifies some of the benefits of shifting demand that is enabled by the Smart Meter rollout, and the resultant enabling of Time of Use Tariffs, at £1.4bn.[**] At least in the near-term this may be an underestimate given that energy prices are now expected to be higher than when this forecast was made.

As described above, Time of Use tariffs will occur in the counterfactual, with our use cases only having the potential to make their take up more prevalent. Therefore, we assume a small proportion of the uplift assumed in the Smart meter CBA:

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§ A Virtual Lead Party is an independent aggregator that controls power generation and/or electricity demand from a range of assets for the purposes of selling Balancing Services to the National Grid Electricity System Operator.

** The Smart Meter CBA assesses the costs and benefits from 2013 through to 2034. It takes the 2019 present values, discounting future costs and benefits at a rate of 3.5% per annum, and uses 2011 as its base price year. It also assumes demand shifting of 1% in 2020, rising to 15% in 2034. We have used these figures to calculate the annual profile of benefits, and extend them out to 2040, at a 2023 price base.

- Use case 2.a: We assume that 0.1% of this figure will be contributed by companies improving their ToU offering. We assume this small percentage because we believe that the majority of this benefit would occur in the factual scenario. This would imply a net present value of £3m.
- Use case 2.b: We assume that PCW and Supplier access to smart meter data plus IOT data will increase this figure by 1%. This would imply a net present value of £29m.
- Use case 2.c: We assume that location-based access to smart meter data plus IOT data will increase this figure by 1%. This would imply a net present value of £29m.

10.4.5 Lower network costs

Use Case 3.a: As described in the smart meter CBA, historical smart meter data allows DNOs to identify areas in the existing network which are at risk and might require reinforcement more easily. For DNOs, half hourly data (as opposed to merely total consumption) is particularly important because they need to understand and forecast peak demand. By being able to better understand if the energy is being stored as heat or electrical energy, when or if that energy may return to the grid and whether there is an efficiency gap in, DNOs will be able to reduce investment costs, leading to an overall societal benefit. The SMIOTS data streams can be aggregated at the same level as smart meter data.

3b. Improved real time load forecast and automation of fast frequency response for DNO

In the counterfactual, DNOs will have access to data feeds from the DCC. Such data must be aggregated in such a way that it ceases to be identifiable with individual consumers' consumption, and is therefore aggregated to the feeder level. This allows DNOs to understand the total demand and, half hourly demand profile on each feeder for the purposes of understanding network constraints and planning investments.

However, access to SMIOTS data could improve these capabilities in two ways:

- First, sometimes DNOs wish to understand whether different feeder configurations would be optimal and hence may wish to aggregate their consumers' data into different groups. The SMIOTS operational data could be aggregated with the same dimensions as the smart meter data allowing for a direct comparison of supply, demand and performance.
- Second, DNOs do not just need to understand the profile of consumption in the present but also need to model how this will evolve in the medium term. SMIOTS could help by allowing them to understand how consumption varies by consumer archetype (building type, appliances) in their area. They could use these different archetypes to model future consumption, for example by seeing how a move towards electric vehicles will change the consumption load.

Quantifying the benefits of improved forecasting of DNO reinforcement requirements

The 2019 Smart Meter CBA quantifies the total benefits from smart meters of reduced network reinforcements at £170m in NPV from 2021 to 2034.[††] Some of these benefits would be realised in the absence of SEDR, since the DNO can understand consumption at feeder level. However, we assume that SEDR facilitates 10% of these benefits, meaning a total net present value of £26m.

10.4.6 Improved regulation and policies

Our final set of use cases relates to uses which allow policy makers to improve the quality of the policies that they are implementing. An improved energy policy making process would ultimately mean that policy measures are better targeted, increasing their benefits to society, and reducing unintended consequences. There are two ways in which SMIOTS could improve the policy making process.

[††] Note that this is a different set of benefits from those described and quantified under use cases 2a and 2b. While any increases in demand-side flexibility will reduce the need for network reinforcement, the electrification of heating and transport will still require significant reinforcement spend, and SEDR may be able to reduce this too.

10.4.6.1 Use case 4a: Improved housing stock and heat pump performance data to drive and target policy

Some energy policies impact not just upon the overall costs faced by consumers, but also how prices vary based on time of day and across the year (for example, the way in which costs such as the balancing system are recovered from consumers).[‡‡] Policy makers could use consumers' load profiles to understand who would experience the highest costs and benefits as a result of such a policy. For example, EV users who consume energy mainly at night would be more affected by a policy which caused prices to increase during this period, relative to other consumers.

Policy distributional impacts may also depend on factors such as overall consumption volume (for example, a policy which had the impact of shifting costs from the standing charge of the bill to the unit rate would help low volume consumers and the expense of those with greater levels of energy usage).

Given the timing and volume of energy usage is correlated with factors such as location, household composition, and income levels, such policies have the potential to redistribute resources. Policymakers faced with multiple policy options will generally consider such effects.[§§]

SMIOT could be used to help policy makers gain a more granular understanding of usage data. This would help to avoid unintended consequences, such as through a policy that negatively impacted owners of green technologies, or people on lower incomes.[***] The depth of the data would also allow for an understanding of the second order impacts of the policy. In other words, it would allow them to understand how usage would change as a response to the change in cost profiles.

This would be possible in the counterfactual. Platforms such as Glow and SERL would contain some consumer archetypes, although with lower sample sizes. However, SMIOT would allow a more fine-grained understanding, for example, by allowing a view of building type and LCT performance.

In addition to a better forward-looking understanding of policy, SMIOT would help policy makers develop a retrospective view of the impact of policy or regulatory changes. This could be done by tracking groups of users' consumption patterns before and after a change. Ultimately, this would make the forecasting of second order policy impacts (e.g. the extent to which a change in now costs are recovered affects decisions on when to consume energy) better over time.

In the counterfactual there would be two options:

- Existing platforms, such as Glow could be used by policy makers.
- SERL is also available to academics who might use this to track, and provide a critique of policies, ultimately influencing how they are implemented in the future.

However, the number of users would again mean that SMIOTS has advantages over these platforms in terms of performance data.

10.4.7 Quantifying benefits of better targeting of low carbon heating measures

There are two potential ways of quantifying the benefits of improved policy:

- The SMIOTS dataset might mean that policy makers' productivity improves, since they would have access to better data, and would take less time to come to the appropriate conclusions.
- Alternatively, the dataset might increase the social value of the policies made, since it would allow policy makers to make better decisions.

[‡‡] For example, see section 3 of Frontier Economics and LCP for Ofgem (2021), *Wider system and distributional impacts of recovering balancing services costs from demand*.

[§§] For example, see Ofgem's *Impact Assessment Guidance*.

[***] Note that although SEDR would not contain data on household income, other proxies such as building type, and location could be used.

In order to provide an illustration of the second of these points, we have carried out a simple calculation to demonstrate how better policy might lead to improved social value: If we assume that policymakers are able to redistribute 0.1% of the energy bills from the lowest earning quintile to the highest earning quintile (by better understanding how different groups are impacted by changes), this would result in roughly a £14m improvement per annum in equity weighted net benefits . This assumes energy bills are at their summer 2021 levels, and uses a marginal utility of income of 1.3, consistent with the 2022 Green Book.[†††] If applied across the useful life of the SMIOTS device, this would result in present benefits of £154m.

Further work would be needed to quantify these benefits more accurately. This is since, unlike the other use cases considered where we have drawn on the smart meter CBA or CCC analysis, there is not an obvious baseline (e.g. relating to the extent to which the existing data available on energy consumption leads to policies having a higher social value). We therefore do not include these figures in our CBA calculations.

10.5 Summary of benefits by use case

The net benefits of each use case described above, are shown in Table 4 and graphically in Figure 4. As described in section 4, we have assumed that SMIOTS will be active from a go live date in mid-2024, for 15 years until mid-2039. As a result, each of the quantified benefits is calculated over this period, with values discounted back to 2023. The most significant benefits are those that relate to better targeting of low carbon technologies, which together contribute over half (£399m) of the NPV benefits.

[†††] HMT (2002) *The Green Book*

Category of use case	Use case name	NPV benefits
1. Better targeting of energy efficiency and low carbon heating measures	1.A. Companies are better able to design and market energy efficiency and low carbon heating measures to customers	£101m
	1.B. Heating installers and fabric retrofit engineers have a better understanding of customers' usage and can install efficiency and LCT technology more effectively	£101m
	1.C. Service companies can measure the performance of LCT technology and optimise its use	£101m
2. Improving Demand side flexibility	2.A. Improving companies' ToU offering	£3m
	2.B. Increased personalisation of tariffs by price comparison websites	£29m
	2.C. Improved real time information for load control and optimisation for function / cost of energy	£9m
	2.D Improved real time information for load control and optimisation for function / cost of energy	£29m
3. Improved forecasting of DNO reinforcement requirements	3.A. Improved real time load forecast and automation of fast frequency response for DNO	£26m
	3.B. Improved long term load forecast and integration into asset planning/optimisation for DNO	(3A covers)
4. Improved policy measures	4.A. Policy makers better understand likely distributional impact of policies	(Not quantified at this stage)
Total		**£399m**

10.6 Cost benefit summary

Given that the benefits assume a very large percentage of take up by the available market, the best way to compare the costs and benefits is on a unit cost / benefit basis. Enhancing that further, a marginal cost benefit analysis could also be valid.

If the assumption is that 10 million (50% of households) SAPC devices deployed would provide the benefit, there is a total cost of £ 558m for the devices. Breakeven number of devices would be 7.1m or a third of all GB households.

Realistically no one manufacturer would dominate the market, therefore cannot deliver all of the benefits. If the IHD and metering market shares are a guide, there are a range from 5% - 50% of market share by manufacturer.

A range of market share estimates for households that would benefit and will have smart meters is used as the basis.

	Devices	Cost	Benefit
5% market share / 30% benefit	950,000	£60m	£119.5m
40% market share / 80% benefit	3,500,000	£192m	£320m

Appendix 4 Glow SAPC overview

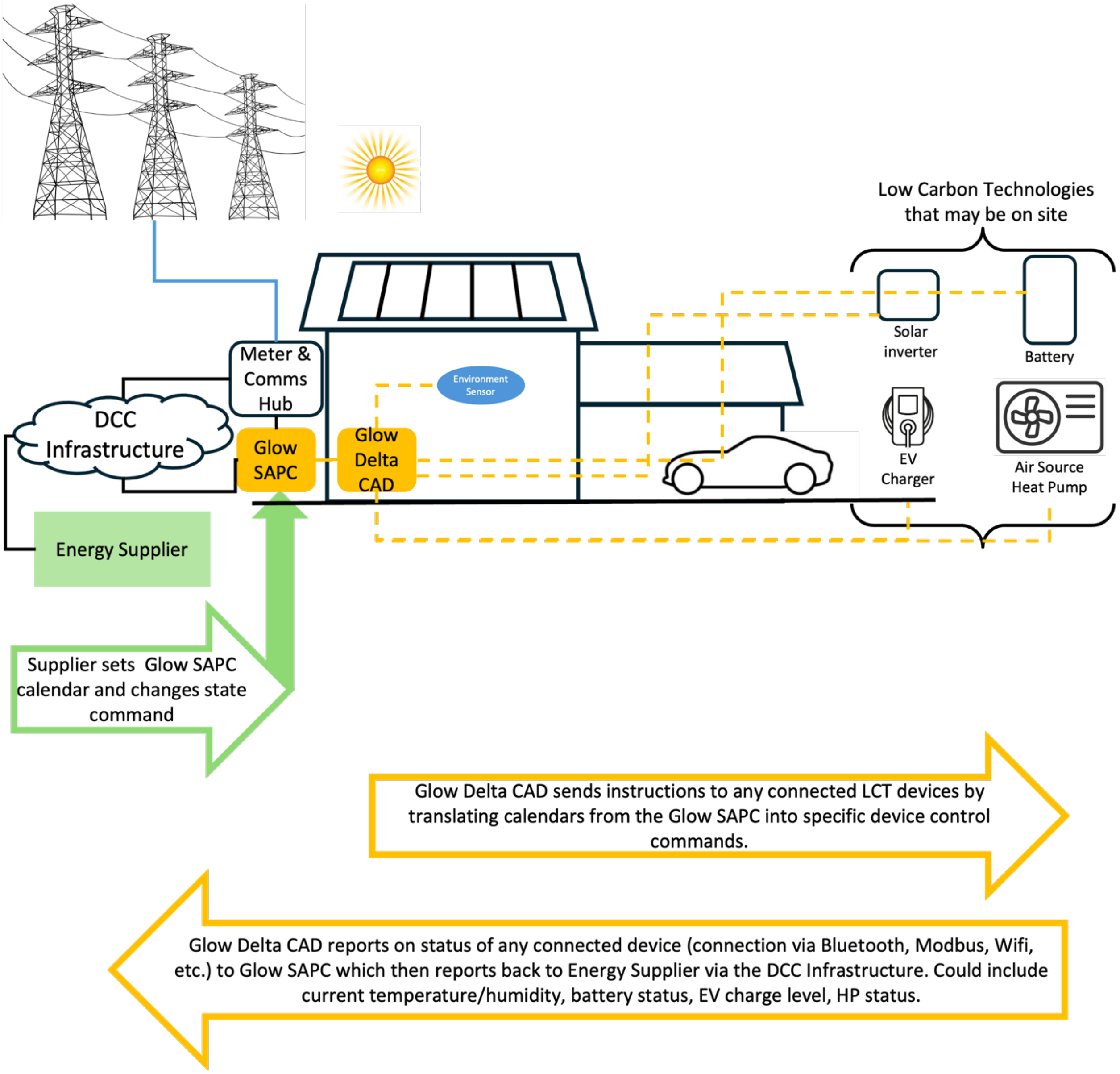
SAPC

The Glow Stand Alone Auxiliary Proportional Load Control (SAPC) solution securely **informs intelligent local control** within the home **with schedules and proportional control settings**. Low carbon technologies on site, for example EV charge point controllers and home automation systems, can continue to independently affect control but are informed by the Glow SAPC about the proportion of load expected. (Works independently of current tariff).

With a SAPC device grid level information and energy supplier/services signals can reliably reach low carbon technology assets within the home and be implemented at scale.

Glow SAPC has two components:

1. Glow SAPC: connects to the meter's Communications Hub (CH), and therefore the DCC infrastructure via the Wide Area Network (WAN). The WAN connects the Energy Supplier to the CH and the Glow SAPC. The Glow SAPC communicates via a wired connection to the Glow Delta CAD or any other Modbus client device.
2. Glow Delta CAD: acts as a translator between any connected devices in the home and the Glow SAPC. It periodically checks the Glow SAPC for instructions on what 'state' it should be in and informs the Glow SAPC on the current status is of any connected device (in-home sensors, LCTs, etc.)



Want to find out more? Contact info@hildebrand.co.uk

SAPC

Who does what?

Energy Supplier

- Sets a calendar/schedule for each Load / Controller that is connected to the Glow Delta CAD
- Calendar could be for HCALCS or APC
- Receives notifications (in the form of alerts) via the Glow Delta CAD about the current status of connected devices
- Overrides calendar(s)/schedules via a 'change state' command for up to 24 hours

Energy consumer

- Tell Energy Supplier what LCT's they have in their home
- Sets their 'rules' for connected devices; e.g. my EV must be fully charged by 0700 on weekdays, 0900 on weekends
- Has ability to override the pre-defined calendar/schedule when required

Use cases supported with a Glow SAPC device

- **Measured fabric performance** – Glow Delta CAD collects internal temperature and humidity data and deposits into Glow SAPC registers daily. Glow SAPC will be triggered on a schedule to transmit an alert back through the Comms Hub which is received by the Energy Supplier. SmartHTC (developed in SMETERS) is calculated from energy used for heating; updated periodically from temperature and humidity profile data.
- **Heat pumps** – Three variants: 1) SmartHTC provides reliable predictor of flexibility offered by HP; 2) interface HP's output to send heat pump performance data (SCOP, energy usage, etc); 3) inform flexibility event/schedule from calendar that will be published onto Glow SAPC.
- **Home batteries** – in conjunction with solar or stand-alone. Two variants: 1) transmit inverter performance data, including battery level back, through DCC systems and 2) inform flexibility or low-cost period schedules for anticipated battery charge/discharge through Glow SAPC calendar functions.
- **EV** – like home batteries, two variants: 1) transmit charge performance data, including EV level back through DCC systems and 2) inform flexibility or low-cost period schedules for anticipated EV charge through Glow SAPC calendar functions. Future scenario may include vehicle to grid discharge of battery through Glow SAPC schedule and transmission of anticipated volume available over time periods, especially when that energy can locally meet demand.
- **Demand response** – demand response schedules can be set by load controller or supplier. Minimal reliance on sending data to Supplier as energy meters report their consumption regardless.

Definitions & abbreviations

ALCS	Auxiliary Load Control Switch
APC	Auxiliary Proportional Controller. Multiple states between 0-100%
CH	Communications Hub
Glow Delta CAD	Device connects to any LCT in the home and sensors; communicates with Glow SAPC
Glow SAPC	Connected to the CH; includes Calendars set by the supplier
HAN	Home Area Network
HCALCS	HAN Connected Auxiliary Load Control Switch (can exist in meter). Binary status – on/off
HP	Heat Pump
HTC	Heat Transfer Coefficient (measures building fabric performance)
LCT	Low Carbon Technology
SAPC	Stand Alone Proportional Load Control
SCOP	Seasonal Coefficient of Performance
SmartHTC	Building fabric loss algorithm (Heat Transfer Coefficient) using temperature and energy data
WAN	Wide Area Network

Appendix 5 Hildebrand social media planning

The following outlines the activities on Hildebrand's LinkedIn page related to the SAPC both past and planned.

Social Plan for the SAPC device - V1

Introduction and narrative

This plan presents the different components needed to promote the SAPC device on social media. Target markets and key messaging will be defined to ensure Glow and our new SAPC device is meeting our target customer needs. Timescales will also be considered but could be subject to change.

Aims

1. To raise awareness of what the SAPC can offer, through posting frequently on social media and launching the new website.
2. Establish and build a robust brand reputation, which will be achieved through engaging and collaborating well with our target audience.

Strategic objective

- Get consumers interested in having a SAPC device
- Ensuring that consumers are not just interested in our device but our brand as a whole

Time scales

21 February 2025: Hildebrand's new device gets Trial Device Certification from the Smart Energy Code's Security Sub-Committee

7 March 2025: Talk about how the device supports flexibility

14 March 2025: Video of installers commentary on doing the install

19 March 2025: SAPC device installed at the Salford Smart Home

End March 2025: SMIOTS project completed, Hildebrand and Octopus were the two that got chosen, Hildebrand device live in homes, thank you to DESNZ for the funding - now the realisation begins!

April 2025: Video of happy trialist in their home saying how battery optimisation been great

Success metrics

1. Number of enquiries for information about the device/Sales number
2. Increase in website traffic
3. Number of followers across social media accounts
4. Reviews

Tactics

- Have socials on website, emails and any other marketing materials to improve follower base
- Push for UGC - help audience build trust in the 'Glow' brand and to prove to others the benefits of the device (Good content could be published as blog article in website)
- Use a range of different types of posts, to promote engagement

Appendix 6 DCC overview of sector initiatives

The following table was prepared by the DCC team and reflects a number of current initiatives they are involved in with their view on the implications for the SMIOTS / SAPC solution. These may have policy implications.

Initiative	Organisation lead	Summary
Asset visibility and flexibility		
Automatic Asset Registration (AAR) / Central Asset Registry (CAR)	Department for Energy Security & Net Zero	Government funded innovation project exploring development of an automatic secure data exchange process for registering small-scale energy assets and enabling access via a central asset register. The project seeks to overcome the challenge of un-registered LCTs and limited visibility for DSOs and local authorities. The innovation project has concluded and government are considering how to progress with any subsequent phase. **Implications for SMIOTS:** - Solution holds potential for retrofit of existing non-smart assets to enable flexibility capability - Devices could be incorporated into any future central asset registry [Withdrawn] Automatic Asset Registration (AAR) Programme (closed to applications) - GOV.UK
Flexibility Market Asset Register (FMAR)	Ofgem	The FMAR is an Ofgem led initiative designed to improve of ease of registration of LCTs into flexibility markets. The programme will be delivered by Elexon. **Implications for SMIOTS** - Future registration of devices into flex markets Flexibility Market Asset Registration | Ofgem
Low Carbon Flex Roadmap (LCFR)	DESNZ	The LCFR is a broad-ranging government policy initiative which seeks to enable a further 29-35GW of flexibility by 2030 (from consumer-led solutions, battery storage and electricity interconnection). The LCFR will set out policies and funding levers required to meet this target, remove barriers and promote coordination across Govt departments and central bodies. **Implications for SMIOTS:** - Monitor for emerging actions and opportunities including funding Clean Power 2030 Action Plan: A new era of clean electricity – main report - GOV.UK
Sector Digitalisation Plan	NESO	In alignment with government's Clean Power 2030 target, NESO is developing a digitalisation plan will identify and map out the digitalisation requirements that are essential to achieve this target. Flexibility forms a key workstream of the plan

<table>
<tr><th>Initiative</th><th>Organisation lead</th><th>Summary</th></tr>
<tr><td></td><td></td><td>Implications for SMIOTS
- Monitor for emerging actions and opportunities

Sector Digitalisation Plan | National Energy System Operator</td></tr>
<tr><td>Smart & Secure Electricity System</td><td>DESNZ</td><td>Summary: The Smart Secure Electricity Systems (SSES) Programme is designed to create the technical and regulatory frameworks that will enable domestic-scale energy smart appliances to be used flexibly by consumers to contribute to demand management across the electricity grid

Relevance to SMIOTS
- Supports evolution of new roles to control load through SM network – enabled through activation of load controller role, planned Licencing of DSRSPs
- Alignment with emerging Energy Smart Appliance standards including cybersecurity at an appliance and potentially systems level (e.g. Common Systems)
- Ensuring PAS1878 is not inhibitive to load control via DCC

Delivering a smart and secure electricity system: the interoperability and cyber security of energy smart appliances and remote load control - GOV.UK</td></tr>
<tr><td colspan="3">Energy efficiency</td></tr>
<tr><td>SMETERs</td><td>DESNZ</td><td>Smart Meter Enabled Thermal Efficiency Ratings (SMETER) is a new methodology for measuring the rate of heat loss from homes (new and retrofit). It is a data led way of measuring the ‘heat transfer coefficient (HTC)’, a critical metric for the energy efficiency of buildings (e.g. to accurately specify and measure the performance of energy efficiency measures such as insulation).

SMETER technologies use algorithms to calculate the Heat Transfer Coefficient (HTC) of occupied homes, using smart meter data (consumption data). Some SMETER technologies also combine data from the meter with data from in home temperature sensors, and external weather data to further enhance the accuracy of the algorithms.

Implications for SMIOTS
- Scalable, secure, reliable and cost-effective retrieval of temperature and humidity data via the SM network can enhance SMETER’s approaches
- Explore opportunities for delivery

Smart Meter Enabled Thermal Efficiency Ratings (SMETER) Innovation Programme - GOV.UK</td></tr>
<tr><td>Warm Homes Social Housing Decarbonisation Fund</td><td>DESNZ</td><td>The Warm Homes Social Housing Decarbonisation Fund (£1.3bn allocation over 3 years to support retrofit) – applications that plan to use SMETER approaches score additional points under the innovation category of the submission. Applications are now closed and being assessed by government.</td></tr>
</table>

<table>
<tr><th>Initiative</th><th>Organisation lead</th><th>Summary</th></tr>
<tr><td></td><td></td><td>Implications for SMIOTS
- Explore opportunities for use of solution capabilities for funded partners planning to use SMETERS approaches

Warm Homes: Social Housing Fund Wave 3 (closed to applications) - GOV.UK</td></tr>
<tr><td>ECO mid-scheme consultation - Pay for Performance</td><td>DESNZ</td><td>A mid-scheme consultation on the Energy Company Obligation has proposed a ‘pay for performance’ uplift for improvements to the energy efficiency of a treated home using a SMETERS approach

Ofgem have responded to the consultation proposing that the change is not enacted.

Implications for SMIOTS
- Lobby Ofgem / DESNZ to enact the change
- Explore opportunities for partnership with energy suppliers seeking to deploy SMETERS methodologies

assets.publishing.service.gov.uk/media/6734835937aabe56c4161036/eco4-and-gbis-mid-scheme-consultation.pdf</td></tr>
<tr><td>SMETERS Validation methodology</td><td>DESNZ</td><td>SMETERS validation methodology summarises a research project designed to establish a methodology through which the accuracy of different SMETER based approaches can be assured. This is necessary so that SMETER applications such as for ECO can be robustly assured. The report describes creation of a ‘technology-agnostic’ tool for SMETER validation.

Implications for SMIOTS
- Evaluate assessment methodology approach to ensure alignment with solution

Smart Meter Enabled Thermal Energy Ratings (SMETER): validation methodology - GOV.UK</td></tr>
<tr><td>Fuel Poverty Strategy Consultation</td><td>DESNZ</td><td>Government is consulting on a new Fuel Poverty Strategy. Proposals including retaining the ‘Vulnerability Principle’ which supports greater

- collaboration across the health and energy sector and could pave the way for further Warm homes on prescription models – for which temperature and humidity data are vital.

Implications for SMIOTS
- Monitor for the emerging fuel poverty strategy
- Explore opportunities for further engagement with Warm Homes on Prescription practitioners and broader projects that are seeking to monitor and minimise risks of damp and mould.

Review of the Fuel Poverty Strategy - GOV.UK</td></tr>
</table>

<table>
<tr><th>Initiative</th><th>Organisation lead</th><th>Summary</th></tr>
<tr><td>Reform the Energy Performance of Buildings Regime</td><td>DESNZ</td><td>Consultation covered include improving the applicability, quality and data usage of energy performance certificates in domestic and non-domestic buildings, refining requirements for energy performance certificates and display energy certificates, and updating the metrics of energy performance certificates. The role of SMETERs methodologies was specifically identified within the consultation in context with future reforms.

Implications for SMIOTS
- Continue to monitor EPC reform and applications for SMETERS

Reforms to the Energy Performance of Buildings regime - GOV.UK</td></tr>
<tr><td colspan="3">Data privacy</td></tr>
<tr><td>Centralised

Consumer Consent solution</td><td>Ofgem</td><td>Ofgem has consulted on the development of a new solution to improve approaches to the management of consumer consent across industry. The Retal Energy Code Company has been identified as the preferred delivery body. Ofgem is targeting the delivery of a Minimal Viable Product by mid-2026

Implications for SMIOTS
- A new consent solution could streamline consumer interaction and consent management.
- Opportunities to participate in solution design through industry engagement activity.

Consumer Consent Solution consultation | Ofgem</td></tr>
</table>

References

[1] https://www.ncsc.gov.uk/information/commercial-product-assurance-cpa
[2] https://assets.publishing.service.gov.uk/media/67446ad2a91ce6ead8e92fa5/Flexibility_Innovation_Programme_-_Smart_Meter_Internet_of_Things.pdf
[3] Ibid
[4] https://assets.publishing.service.gov.uk/media/67446ad2a91ce6ead8e92fa5/Flexibility_Innovation_Programme_-_Smart_Meter_Internet_of_Things.pdf

[6] https://assets.publishing.service.gov.uk/media/67d95f7c4ba412c67701ed58/Q4_2024_Smart_Meters_Statistics_Report.pdf
[7] https://smartenergycodecompany.co.uk/
[8] https://smartenergycodecompany.co.uk/assessment-process/
[9] https://smartenergycodecompany.co.uk/documents/sec-section-guidance/sec-section-f-smart-metering-system-requirements/
[10] https://smartenergycodecompany.co.uk/glossary/great-britain-companion-specification/
[11] https://www.neso.energy/industry-information/balancing-services/demand-flexibility-service-dfs
[12] https://www.postman.com/what-is-an-api/
[13] https://en.wikipedia.org/wiki/Modbus
[14] https://www.csimn.com/CSI_pages/Modbus101.html
[15] https://www.techtarget.com/whatis/definition/narrowband-IoT-NB-IoT
[16] https://www.gov.uk/government/publications/smart-meter-enabled-thermal-efficiency-ratings-smeter-technologies-project-technical-evaluation
[17] https://www.openadr.org/assets/docs/DTECH2015/what%20is%20openadr.pdf
[18] https://assets.publishing.service.gov.uk/media/6659f0147b792ffff71a8601/smart-secure-electricity-systems-2024-energy-smart-appliances-consultation.pdf
[19] See SMIOT Deliverable 2.1 Technical Report Version v1.2.docx
[20] https://www.insidehousing.co.uk/comment/why-the-social-homes-of-the-future-must-be-energy-smart-88834
[21] Limiting the number of interfaces and their format (for example, not over WiFi) reduces the risk of unwanted access to the device and improves the likelihood of achieving CPA.
[22] https://www.gridx.ai/knowledge/home-energy-management-system-hems
[23] https://smartenergycodecompany.co.uk/glossary/great-britain-companion-specification/
[24] https://www.home-assistant.io
[25] https://cytal.co.uk/products/protocrawler/
[26] https://www.dlms.com/
[27] https://smartenergycodecompany.co.uk/documents/sec-section-guidance/sec-section-f-smart-metering-system-requirements/
[28] https://www.ncsc.gov.uk/schemes/commercial-product-assurance-cpa
[29] https://www.ncsc.gov.uk/schemes/commercial-product-assurance-cpa
[30] https://www.neso.energy/industry-information/balancing-services/power-responsive/demand-side-response-dsr
[31] https://www.gridpoint.com/blog/what-is-automated-demand-response-exactly/
[32] Detailed survey responses can be found in the SMIOTS Feasibility Report and Phase 2 Proposal.
[33] https://www.investopedia.com/terms/v/valueproposition.asp
[34] Hickel, 2016; Committee on Climate Change, 2018
[35] https://www.london.gov.uk/programmes-and-strategies/environment-and-climate-change/energy/energy-londoners/home-response-supporting-smart-energy-use-london
[36] https://www.london.gov.uk/sites/default/files/d23_27_-smart_metering_infrastructure_integration_assessment.docx.pdf
[37] https://www.london.gov.uk/sites/default/files/d23_27_-smart_metering_infrastructure_integration_assessment.docx.pdf
[38] Jay Saggar – Programme Manager: Data, Smart Cities & Cyber Security, London Office of Technology Innovation
[39] https://www.gov.uk/government/publications/smart-meter-enabled-thermal-efficiency-ratings-smeter-technologies-project-technical-evaluation
[40] https://www.theccc.org.uk/publication/sixth-carbon-budget/

[41] Tariffs where the rate paid for electricity varies based on the time in which it is consumed. ToU tariffs can be static (like Economy 7, where the time bands and associated prices are announced well in advance) or dynamic (where the prices can change with less notice).
[42] See Axle Energy as an example of an asset optimiser, https://www.axle.energy/
[43] The Smart Meter CBA assesses the costs and benefits from 2013 through to 2034. It takes the 2019 present values, discounting future costs and benefits at a rate of 3.5% per annum, and uses 2011 as its base price year. It also assumes demand shifting of 1% in 2020, rising to 15% in 2034. We have used these figures to calculate the annual profile of benefits, and extend them out to 2040, at a 2023 price base.
[44] https://annex94.iea-ebc.org/
[45] https://annex96.iea-ebc.org/
[46] https://www.ofgem.gov.uk/energy-policy-and-regulation/policy-and-regulatory-programmes/network-price-controls-2021-2028-riio-2/network-price-controls-2021-2028-riio-2-riio-2-network-innovation-funding/strategic-innovation-fund-sif
[47] https://ukerc.ac.uk/
[48] https://energy-poverty.ec.europa.eu/system/files/2024-05/EPAH_Energy%20Poverty%20National%20Indicators%20Report_0.pdf