Appendices

Appendix A: Project Plan

Appendix B: Project Risk Register

Appendix C: Year on Year project costs ED1 & ED2

Appendix D: Calculation of Carbon Benefits

Appendix E: Calculation of Costs and Benefits for Rejected Roll-Out Scenarios

Appendix F: Enhanced Secondary Substation Monitoring Specifications

Appendix G: Data sheet of LV substation common application platform

Appendix H: SPEN “Flexible Networks for a Low Carbon Future” project summary

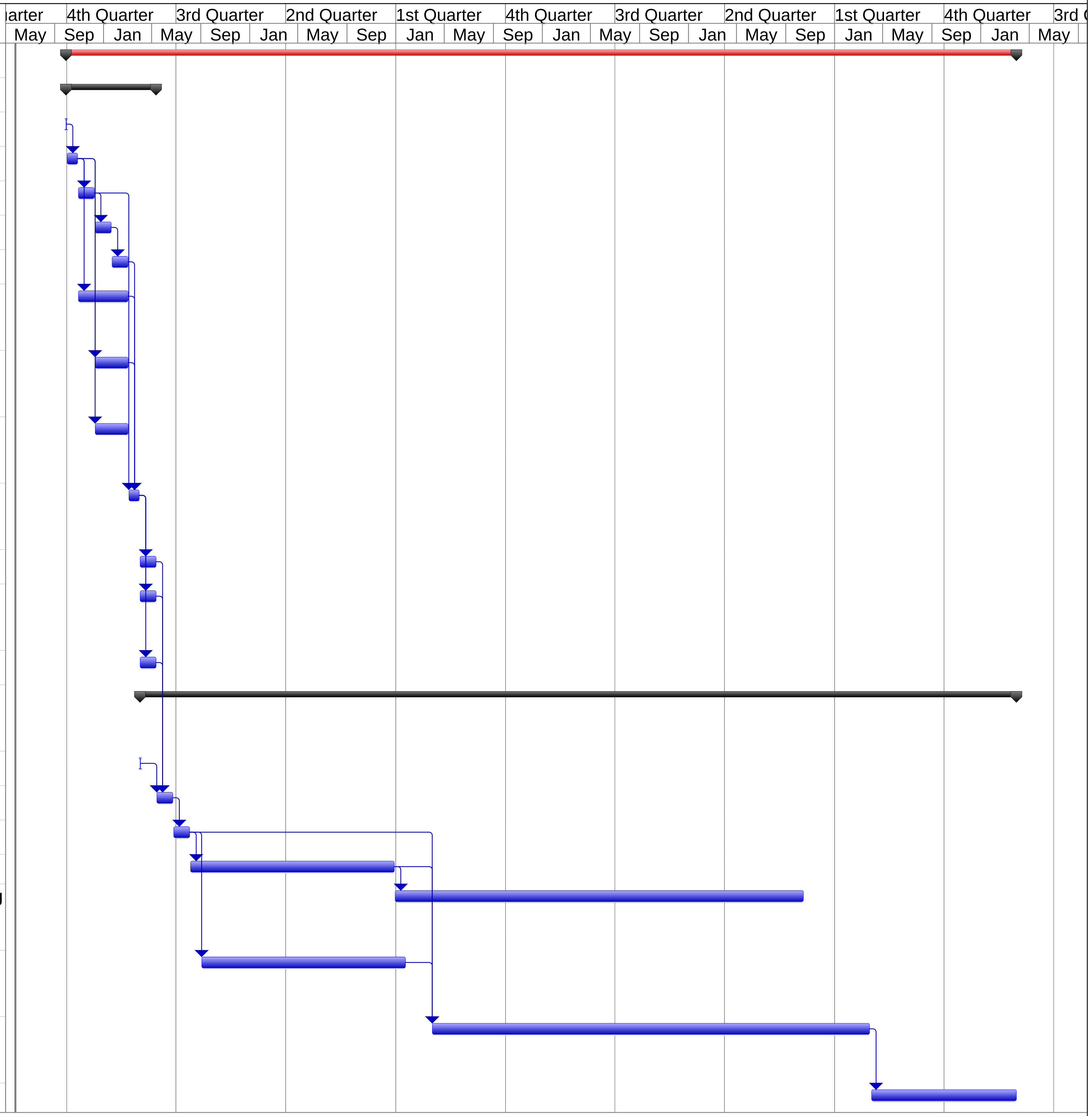
Appendix I: Evidence from ESSM roll out in Spain

Appendix J: Grid Key example product documentation

Appendix-A Project Plan

Enhanced Secondary Substation Monitoring System Deployment in SPD network

ID	Task Name
1	**Enhanced Secondary Substation Monitoring Project**
2	**Phase -1 (Design Engineering, Bid invitations and evaluations)**
3	IRM funding confirmation by Ofgem
4	Develop Detailed Project Plan & Internal Resource allocation
5	Development of formal Request for Information (RFI) for ESSM
6	Issue RFI
7	Review RFI Responses
8	Review of existing central data systems and mapping the compatibility requirements for ESSM data
9	Review of existing substations characteristics and detailed assessment for ESSM depolyment
10	Detailed assessment of 2G/3G network coverage in vicinity of existing substations
11	Preparation of tender documents for ESSM unit procurements, Central data system upgrade and data communication systems
12	RFP invitation for supplying ESSM units along with necessary accessories
13	RFP invitation for upgradation of Central data systems and analytics interface with existing PI data base
14	RFP invitation for supply of 2G/3G/4G enabled data simcards
15	**Phase -2 (Procurement, Mobilization, Installation and comissioning)**
16	Funding release by Ofgem
17	Contractual negotiations with bidders
18	Commercial agreements and award of contract to successful bidders
19	Equipment Supply Lead Time
20	Manufacturing of ESSM units for ED1 along with Sensors and accessories (including FAT)
21	Development and comissioning of Central Data System & Communication interface logics (including FAT & SAT)
22	Installation, testing and comissioning of ESSM units with sensors, accessories and 2G/3G simcards (including SAT)
23	ED2 Programme



Project: Enhanced Secondary Substat
Date: Fri 26/05/17

Task	Project Summary	Inactive Milestone	Manual Summary Rollup	Progress
Split	External Tasks	Inactive Summary	Manual Summary	Deadline
Milestone	External Milestone	Manual Task	Start-only	
Summary	Inactive Task	Duration-only	Finish-only	

Appendix-B: ESSM Project Risk Register

Risk	Explanation of Risk	Mitigation Strategy
Integration Risk	• Integration with SPEN's central data systems fails • New monitoring approach not adopted by other parts of the business	Extensive internal stakeholder engagement during the IRM bid stage has gathered significant internal support for the new monitoring approach. Regular reviews during design phase and critical co-ordination with central data system design.
ESSM Technology Performance	• Quality issues may occur in initial product delivery • ESSM units not meeting performance requirements • Low cost current sensors (Rogowski Coils) don't meet accuracy requirements	Programme allows significant time for suppliers to deliver a gradual Ramp up of volumes, and small initial installation volumes to mitigate technology risk and address "teething" issues.
Cyber security/data privacy	• System is hacked or system data exposed. • Individual data privacy breach.	Proposed monitoring scheme does not collect individual data on any customers as monitoring takes place on the aggregated secondary network flows. ESSM units and central system fundamentally designed with cyber security requirements in mind. Data collection layers should be tamper proof, the gateway/collection layer is super secure. Each layer has its own access control appropriate to need.
Programme Risk	• Procurement process becomes protracted. • Suppliers can't ramp up to the volumes fast enough. • Resource constraints affect ability to meet proposed installation plan.	Significant time has been allocated in the programme to enable the procurement process to be conducted effectively The project plan has a deliberately slow front end start to allow for supplier set-up time and a gradual ramp up of volumes. External resources will be used for the bulk of the installations. Current indications are that the market will be able to provide the required resources.
Comms Failure	• Cannot retrieve data from ESSM devices	In the case of a temporary comms failure the ESSM device provides local data storage up to 6 months. In the case of Permanent comms failure to some units, the business case is robust to a number of units failing to communicate. Manual readings for some data is also an option – a built –in algorithm will mimic the conventional MDI tell-tale approach
Price Escalation	• Risk of price increases compared with those included in the submission.	Prices are based on informal estimates from 3 vendors. This is a healthy market and the number of potential vendors is increasing, so high levels of competition are anticipated. The proposed technology is not vendor specific and a competitive procurement process will be run to ensure best value is achieved.
Supply chain failure	• Supplier goes out of business or exits the market	Multiple vendors avoids exposure to single source of supply
Failure to meet future needs	• LCTs don't materialise in the expected volumes	Value of monitoring will be reduced in the short term but benefit will still be derived when load growth does occur. Monitoring will also provide benefits in other areas (losses, power quality, CI/CML reduction)

Appendix-C: Year on Year Project Costs ED1 & ED2

SPD

	ED1								ED2							
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
CAPEX Spread	[redacted]															
Monitoring unit installation	[redacted]															
Cumulative units installed	[redacted]															
Spend (CAPEX)	[redacted]															
Spend (OPEX)	[redacted]															
ED1 *Planned* Monitoring Costs	[redacted]															
ED1 *Planned* reinforcement*	[redacted]															
Avoided reinforcement	[redacted]															
NET Monitoring COSTs	[redacted]															
IRM figure requested	[redacted]															

* Only LCT related reinforcement costs are considered

SPM

	ED1								ED2							
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
CAPEX Spread	[redacted]															
Monitoring unit installation	[redacted]															
Cumulative units installed	[redacted]															
Spend (CAPEX)	[redacted]															
Spend (OPEX)	[redacted]															
ED1 *Planned* Monitoring Costs	[redacted]															
ED1 *Planned* reinforcement*	[redacted]															
Avoided reinforcement	[redacted]															
Avoided CIs & CMLs	[redacted]															
NET Monitoring COSTs	[redacted]															
IRM figure requested	[redacted]															

* Only LCT related reinforcement costs are considered

Appendix-D: Calculation of Wider Benefits

1.1 Calculation of Carbon Benefits

traded carbon price (£/t 2012/13 price	7.30	81.73	87.51	95.07	102.63	110.20	117.76	125.32	131.80	139.37	146.93	154.49

Average Annual Energy Consumption (per domestic	3300	kWh
Number of Customers (SPM)	1500000	
Number of Customers (SPD)	2000000	

Licence Area	Max Demand (MW)	Annual Demand (aprox)	Load Growth Enabled by Monitoring		CO2 (tons)
SPM	3041	4950000 MWh	8.0%	396000 MWh	36333
SPD	3626	6600000	8.0%	528000 MWh	48444

Assumed Benefit by LCT (g/kWh) 91.75

Carbon Benefits (g/kwh)		
SPM	MWh	396000
	CO2 (t)	36333.0
	£	**265348.9**
SPD		
	MWh	528000
	CO2 (t)	4844.4
	£	**35379.9**

1.2 Calculation of Avoided CI/CML Benefits

CI / CML Calculations	SPD	SPM
[redacted]		

Appendix-E: Calculation of Costs and Benefits for Rejected Roll-Out Scenarios

<u>Scenario 1: Limited Monitoring</u>

The cost benefit analysis for this scenario is performed considering the following:

- Existing 3400 MDI's (1700 each in SPD and SPM) will be replaced with the ESSM units starting from 2019/20 and the replacements are expected to be completed by 2022/23.

- Considering the projected load growth the deferred additional capacity reinforcement costs are expected to be reinvested starting from 2026/27 in SPD and 2028/29 in SPM.

Table 1 below summarizes the cost benefit analysis for the limited monitoring scenario.

Table 1. Breakdown of project costs and capacity benefits from limited monitoring

Costs	Cost ($£_{12/13}$m) SPD		Cost ($£_{12/13}$m) SPM	
	ED1	ED2	ED1	ED2
Equipment and installation (CAPEX)	[redacted]			
Data communication (OPEX)				
Total (CAPEX + OPEX)				
Benefits	SPD		SPM	
Additional capacity headroom in kVA	[redacted]			
Avoided reinforcement cost (£m) in ED1				
Avoided reinforcement cost (£m) in ED2				
NPV (£m) 16 years				

The limited monitoring scenario enables additional capacity headroom of XXXX each in SPD and SPM which is worth XXXX as per BaU conventional reinforcements. Considering the projected demand growth, the additional capacity headroom realised by virtue of replacing the existing MDI's with ESSM units enables in deferring the conventional reinforcements till 2026/27 and 2028/29 in SPD and SPM respectively. The limited monitoring scenario demonstrates a positive NPV of XXXX in SPD and XXXX in SPM for 16 years payback period.

<u>Scenario 2: Delayed Monitoring</u>

The cost benefit analysis for this scenario is performed considering the following:

- Phase-1: existing 3400 MDI's (1700 each in SPD and SPM) will be replaced with the ESSM units starting from 2019/20 and the replacements are expected to be completed by 2022/23.

- Phase2: additional 12274 and 8921 MDI's in SPD and SPM respectively will be replaced with the ESSM units starting RIIO-ED2 (2024/25) and the replacements are expected to be completed by end of RIIO-ED2.

- Phase1 deferred additional capacity reinforcement costs are expected to be reinvested starting from 2026/27 in SPD and 2028/29 in SPM.

- Phase2 deferred additional capacity reinforcement costs are expected to be reinvested starting from 2030/31 in SPD and SPM.

Table 2 below summarizes the cost benefit analysis for the delayed monitoring scenario.

Table 2. Breakdown of project costs and capacity benefits from delayed monitoring

Costs	Cost ($£_{12/13}$m) SPD		Cost ($£_{12/13}$m) SPM	
	ED1	ED2	ED1	ED2
Equipment and installation (CAPEX)	[redacted]			
Data communication (OPEX)				
Total (CAPEX + OPEX)				
Benefits	SPD		SPM	
Additional capacity headroom in kVA	[redacted]			
Avoided reinforcement cost (£m) in ED1				
Avoided reinforcement cost (£m) in ED2				
NPV (£m) 16 years				

The delayed monitoring scenario enables additional capacity headroom of XXXX and XXXX MVA in SPD and SPM respectively which is worth XXXX as per BaU conventional reinforcements. Considering the projected demand growth, the conventional reinforcements are deferred till 2026/27 and 2028/29 from phase1 ESSM unit deployments in SPD and SPM respectively. The phase2 ESSM unit deployment enables to defer the conventional reinforcement's till the end of RIIO-ED2. The delayed monitoring scenario demonstrates a positive NPV of XXXXX in SPD and XXXXX in SPM for 16 years payback period.

Appendix-F: Enhanced Secondary Substation Monitoring - Device Specification

1. SCOPE

This specification details SP Energy Networks (SPEN) requirements for a substation monitoring device which will be retrofitted to existing ground-mounted and larger pole-mounted (i.e. >=200kV) secondary substations.

2. ISSUE RECORD

This document is controlled.

Date	Issue No	Author	Amendment Details
March 2017	Initial Draft B	Alan Collinson	Evolved from the previous “Smart MDI” specification, dated December 2015.
May 2017	Revised Draft D	Alan Collinson	Stakeholder feedback incorporated

3. ISSUE AUTHORITY

Author	Owner	Issue Authority
Alan Collinson Lead Engineer Commercial & Innovation	Gerry Boyd Manager Commercial & Innovation	Gerry Boyd Commercial & Innovation Manager Network Performance and Regulation

4. CONTENTS

5. INTRODUCTION

This specification details SP Energy Networks (SPEN) requirements for a substation monitoring device which will be retrofitted to existing ground-mounted and larger pole-mounted (i.e. >=200kV) secondary substations.

The device will be a single unit for the measurement of voltage and current. It will be based on open platform hardware and operating system (such as LV-CAP or equivalent) to allow third-party applications (such as a Smart MDI App or equivalent) to run on the operating system.

SPEN require two-way communications functionality, with the capability of sending data to a remote server in one direction and configuration settings and software upgrades in the other. This is expected to be via GPRS/3G/4G communications and must be in line with SPEN cyber security policies.

The supplier may offer alternative solutions which provide the same monitoring outcome, with details of any additional functionality and cost difference/benefits.

6. MEASURING REQUIREMENTS

The device will be used in secondary substations for measuring three-phase LV busbar voltage, plus the three-phase currents of up to 5 outgoing LV feeders in ground-mounted installations and up to 2 outgoing LV feeders in pole-mounted installations. The recorded values will be stored within the device for local or remote download.

6.1. Voltage Measurement

The device will be capable of measuring the voltage on each phase of a three phase system. This will be directly from the LV system at 400/230VAC.

The device will be capable of providing maximum, minimum, average and 'snapshot' of the RMS voltage measurement and store the values in non-volatile memory.

6.2. Current Measurement

The device will be capable of measuring the current of each phase of a three phase LV feeder for up to 5 LV feeders.

The device will be capable of providing maximum, minimum, average and 'snapshot' of the RMS current measurement and store the values in non-volatile memory.

The current input to the device will be supplied from current transducers attached to the individual phase conductors of each LV feeder. The LV feeder currents will typically be in the range:

- Network distribution substation: 0 - 600A.
- Single customer (commercial/ industrial) customer: 0 -1200A
- Pole-mounted transformer: 0 - 400A

The supplier may offer alternative current input sensors, however these must be able to be fitted without dismantling the LV switchboard.

6.3. Power Factor

The device will record the power factor of each phase and store the values in non-volatile memory.

6.4. Electrical Export/Import Numbering Convention

The device will record and label current values that are being “imported” as negative figures.

6.5. Calculation intervals

The measurement calculation interval will be programmable, being 1 second, 1 minute, 10 minutes (the default setting) and 30 minutes.

7. DISPLAY

The device will incorporate a local display function for the instantaneous RMS Voltage and Current Measurements for each individual feeder and the aggregated current for each phase of the transformer. The display will also be capable of showing the maximum values, as calculated by the internal Smart Maximum Demand Indicator App.

8. MONITOR DEVICE SITING

The monitoring device will be installed in several substation configurations and must be of a suitable design for the environment. It must be able to operate normally under vibration or shock conditions which would normally be encountered in service.

The envisaged siting scenarios are listed below:-

- Indoor, surface (wall) mounted as required
- Indoor, recessed mounted on a plate/bracket as required
- Within the space available in a LV distribution cabinet
- Within the space available in a LV feeder pillar
- Outdoor, pole-mounted, with additional weather-proofing required

In many circumstances space for locating the device is limited. Preference will be given to smaller devices which ease installation. The space dimensions required for the device must be stated.

The monitoring device and any auxiliary communications equipment should be accommodated in a single housing where necessary. The option of an external aerial connection for weaker signal areas is acceptable. The housing will be constructed of suitable materials for the above installation scenarios and have a minimum IP54 rating for indoor installations and IP65 for outdoor installations.

Metallic enclosures will need an earthing facility.

9. INSTALLATION

The monitoring device, including voltage sensors and current sensors, must be capable of being installed safely under live working conditions, i.e. without requiring a circuit or transformer outage, fuse removal or dismantling of any of the live elements of the LV switchboard.

10. MAINTENANCE & WARRANTY

Any maintenance requirements of the monitoring equipment shall be specified by the supplier with details and frequencies. Preference will be given to devices requiring no maintenance.

Details of the warranty offered for the monitor and ancillary devices must be stated.

11. TRAINING AND TECHNICAL SUPPORT

Training shall be provided by the supplier for the safe installation, commissioning and use of the equipment with documentation provided. The supplier shall detail the level of technical support for their product, including arrangements for firmware update.

12. DATA RECORDING & COMMUNICATION

All calculated data will be stored within the monitoring device for a minimum period of six months. Loss of power to the monitoring device shall not be detrimental to the stored data.

The recorded data will be time-stamped using the device real time clock. The device real time clock will be able to be synchronised remotely via the communications protocol.

An industry standard data connection port will be available on the device for local data access and device configuration using a standard laptop PC, tablet or Smart phone. Software tools for configuration and data access will be provided.

The device will be capable of downloading the stored data to a laptop PC (or tablet or Smart phone) for both local examination and later transfer to a data server.

The device will be capable of sending data to a remote data server in an industry standard format on a periodic basis (with periods being able to be set by the user) and have the capability of transmitting data upon a remote call request.

An integral GSM/GPRS/3G/4G modem (using industry standard SIM cards) should be provided within the device to send data. The device should have the facility for an external aerial to be connected for difficult signal situations.

13. PERFORMANCE REQUIREMENTS

13.1. Inputs

Voltage Input	230VAC
Frequency	50Hz nominal
Current Input sensors	Current Transformer, Rogowski Coil or equivalent
Current Range	0-400A, 0-600A (default), 0-1200A. Programmable
Accuracy	Voltage ≤1.0% at full scale and reading Current ≤2.0% at full scale and reading (down to 5A)

13.2. Recording

Sampling Method	Preferred sampling method shall comply with BS EN 61000-4-30
Data values log	1 sec, 1min, 10min (default), 30 min values

13.3. Measurements

Voltage	to BS EN 61000-4-30
Current	to BS EN 61000-4-30
Power Factor	to BS EN 61000-4-30
Harmonics – total harmonic voltage distortion	to BS EN 61000-4-30

13.4. Real Time Clock

Crystal	Temperature Compensated
Drift	<4ppm (~2s per week)
Synchronisation	by remote clock via comms

13.5. Data Storage

Storage capability	>6 months data
Storage Medium	Solid state Memory

13.6. Communications

Communication Compatibility	GPRS, GSM, 3G, 4G
Communication/data format	DNP3 / CSV
Local data download port	Industry standard port (e.g. mini USB, optical, wireless, bluetooth)
Local comms compatability	Wireless or Bluetooth

13.7. Power Supply

Power Supply	from voltage input (230VAC @ 50Hz nominal)
Isolation	$3.0kV_{ac}$

13.8. Environment

Operating Temperature	-20°C to 60°C
Relative Humidity	Up to 95% non-condensing
IP Rating	IP54 minimum (indoor) IP65 minimum (outdoors)

13.9. EMC

Radiated Immunity	BS EN61000-4-3 10V/m Criteria A
Radiated Emissions	BS EN55011 Class A
Conducted Immunity	BS EN6100-4-6 10V/m Criteria A
Conducted Emissions	BS EN55011 Class A
EFT	BS EN61000-4-4 Supply 2kV Criteria A Voltage Inputs 2kV Criteria B
ESD	BS EN61000-4-2 Contact Discharge 4kV Air Discharge 8kV

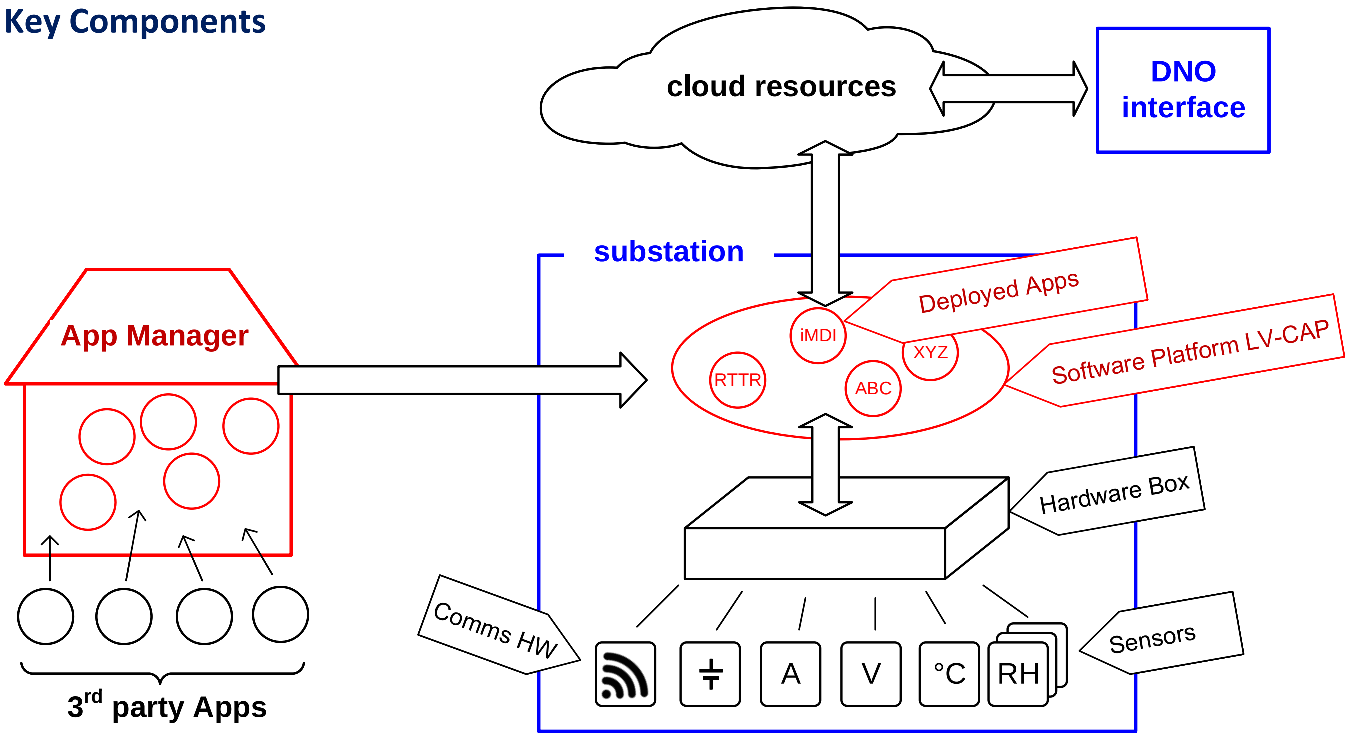
13.10. Safety

Must comply with BS EN 61010

Appendix-G LV CAP Datasheet

LV-CAP ™ :: LV Substation - Common Application Platform

Key Components



LV-CAP ™ Platform

LV-CAP is a software platform, similar in concept to Google's Android or Apple's iOS, but for an electricity distribution substation.

The platform can sit on a variety of vendors' hardware products, and is capable of hosting Applications (or 'Apps')

The Apps can be created by an array of manufacturers, developers and academics – there is a public API to allow others to do this (like Google's Android or Apple's iOS).

The business case for an electricity Distribution Network Operator (DNO) is to allow them to deploy a single hardware unit per substation, incorporating a tailored suite of Apps, rather than deploying multiple devices in each substation, which implement functionality in different, incompatible ways, increasing both purchase and up-stream costs.

LV-CAP opens up additional potential revenue streams for DNOs by enabling real-time network data to be shared with third parties.

LV-CAP provides an upgrade platform and path for enhancing the capability of the substation, whilst minimising the risk of stranded assets.

The business case for an App developer, researcher, manufacturer or service provider is that this provides a route to market with significantly lower hardware costs / barriers to entry in getting products into electricity substations.

Appendix H: SPEN Flexible Networks Project Summary

Flexible Networks delivered all six successful delivery reward criteria, providing a robust framework within which to select and deploy one or a number of innovative techniques collaboratively to techno-economically release incremental network headroom.

SPEN was awarded £3.6M in 2011 by Ofgem to carry out Flexible Networks for a Low Carbon Future with the project commencing in January 2012. A further £2.588M was invested by SPEN with some additional contribution (£174k) from project partners.

Three areas of our network with known capacity issues were identified which provide an opportunity to analyse and implement alternative flexible solutions to network reinforcement see Figure 1. All three sites have different but representative characteristics and customer demographics, and are similar in that they have near-term constraints due to increasing demand and an uptake of low carbon technology. The rapid nature of these changes both imposes a requirement, but also provides the opportunity to trial solutions that are faster and more cost-effective to implement than traditional reinforcement.

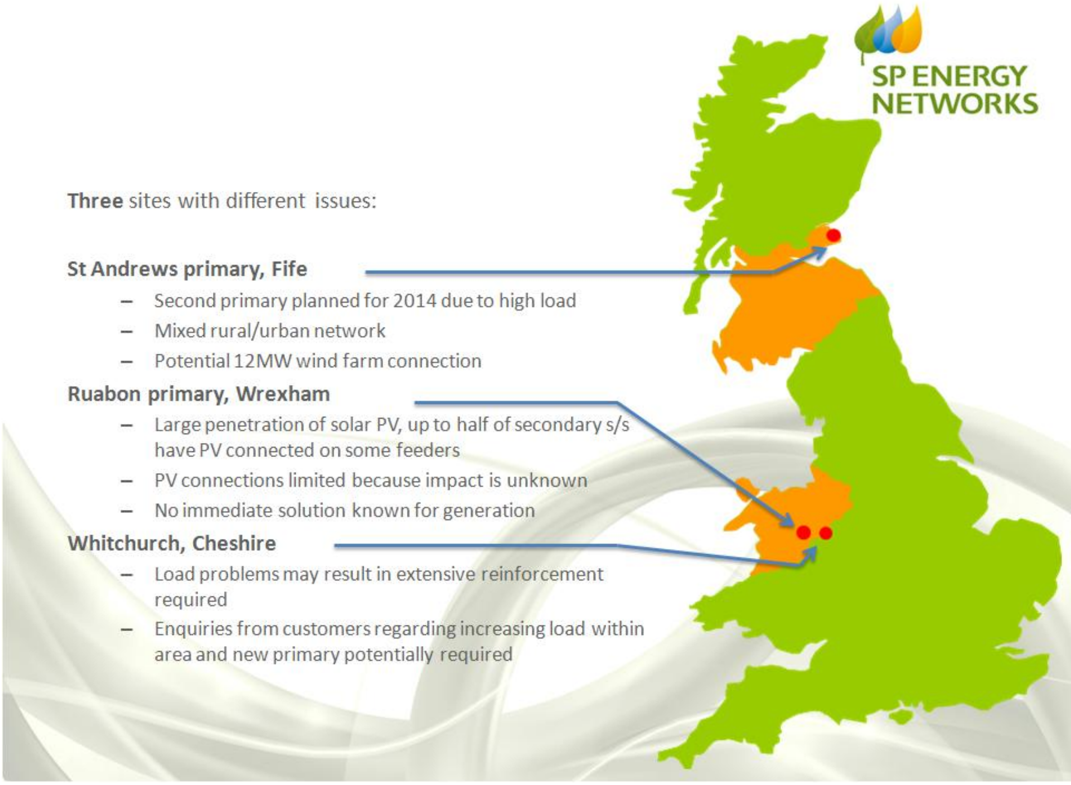


Figure 1 Trial Area Location Map

The specific issues facing us in these three locations are mirrored across the UK electricity distribution network, and this project provides generic solutions and recommendations to address these. For the learning to be relevant, representative and robust, it is essential that there is a strong focus on verification of the trials.

1.1.1 Aims and objectives

Flexible Networks for a Low Carbon Future aimed to provide network operators with economic, DNO-led solutions to increase and enhance the capability of the networks. These would be capable of being quickly implemented and help to ensure that the networks do not impede the transition to a low carbon future. Learning outcomes from Flexible Networks would inform intelligent future network change management.

It is recognised that there are some inherent conflicts between the ideal design, operation and management of a distribution network. A significant advantage to applying a more holistic approach, as developed through Flexible Networks is that it facilitates interaction between business functions, planning, operations and asset management, to optimise the tools and techniques developed.

The objectives of the various activities (work packages) were as follows;

- Develop an enhanced network monitoring methodology and based on this network data, develop and integrate improved DNO planning and operations tools and practices that are optimised for future low carbon networks and use of the innovative techniques being trialled,
- Trial novel technology measures for improved performance of the network such as dynamic thermal ratings of assets, voltage optimisation, and flexible network control,
- Identify the measures by which material improvements in the cost-effectiveness of accommodation of future energy needs can best be demonstrated,
- Develop an investment and future roll-out plan where appropriate cost-benefit exists,
- Disseminate learning to key stakeholders such as customers and other DNOs to ensure sustainable user adoption, through future technical and regulatory policy changes for example.

Based on the findings from the three trial networks the various innovative techniques provided the following capacity gain benefits:

Table 1 – Potential capacity release from flexible network trials

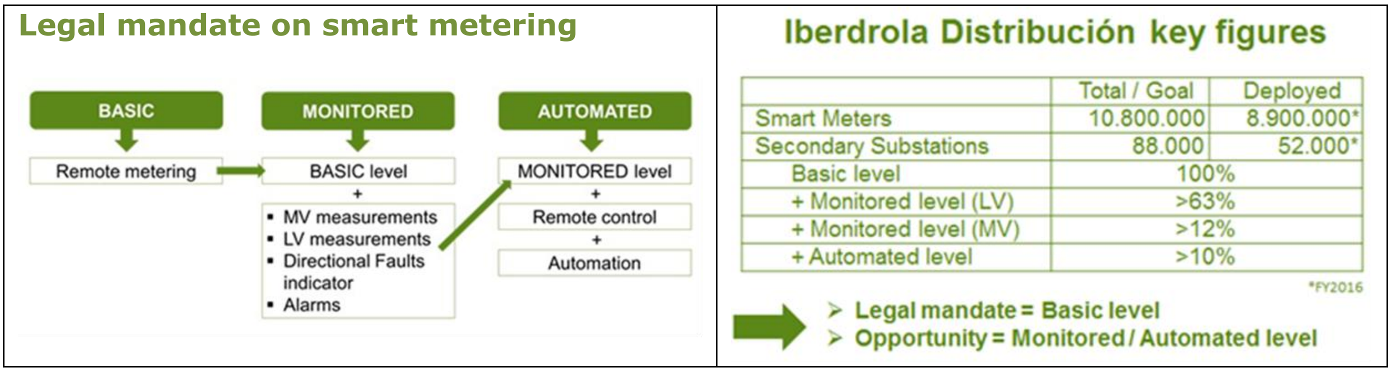
Innovation	Potential capacity headroom release
Enhanced network monitoring	8% on average
Enhanced primary transformer thermal rating	10 -14%
33kV Overhead line RTTR system	Up to 11%
Flexible network control	6 - 11%
Integration of voltage regulators	Enabler
Energy efficiency	Negligible
Voltage optimisation	Demand: 1% for 1% voltage reduction Generation: > 850W per customer for LV networks with embedded PV generation

In terms of future monitoring strategy on the LV network, recommendations were made to the business for "smart" MDIs to be deployed to secondary substations at key locations across the LV network identified through application of the LCT Network Monitoring Strategy. More detailed monitoring will be specified for critical network locations with high levels of low carbon clustering.

Appendix I: Evidence from ESSM Roll Out in Spain

LV supervision functionality:

- Power flow per LV feeder and phase
- Earth leakage detection
- Power quality according to IEC 61000-4-30
- Blown fuse detection
- Overcurrent and short-circuit detection
- LV visualisation (power quality events, blow fuse, etc.)
- Customer meter connectivity per LV line and phase



Pilot of 500 installations completed, with a plan to install 9000 units by 2020.

STAR Project Vision

Smart systems (business as usual): efficiency

LV	Network planning	→	Granular forecast for short term secondary subs
LV	QoS and Operation	→	LV Control System: similar to MV Operation
LV	Maintenance/Renewal	→	Crew automatic dispatch/Asset management model
MV LV	Losses	→	Balance phases & lines load: grid reconfiguration/fraud

Management of active network: "no regret actions"

MV LV	DER/Active Demand	→	Optimize operation with DER and solve constraints
LV	Grid design	→	Interaction and automation
	Customers	→	Information and services

For a 5-feeder configuration the cost is around XXXX for the local controller RTU and XXXX per feeder. Telecoms equipment plus installation and commissioning costs takes the total in the pilot to **XXXX**. The figure is expected to be less for the main rollout.

The data goes to the smart metering system together with the information from the smart meters. The information is collected and stored centrally, taking all the necessary cyber security requirements applicable to Smart Grid solutions.

The telecommunications access is a blend of different telecoms solutions, both based in private and commercial existing solutions. The private part leverages the private telecoms core for operational purposes and brings it close to the border (secondary substations with Broadband Power Line –BPL- solutions; the commercial part uses cellular services from Telcos in a well proven architecture using two SIM cards in the wireless 2G/3G routers, and also leverages wireline ADSL Telco services.

Appendix-J Grid Key example product documentation

GridKey
Continuous substation monitoring

Unlocking the smartgrid
A collaboration between Lucy Electric and Sentec

Overview

GridKey has been producing electrical monitoring systems since 2012 with more than 1100 systems now deployed and operational. Designed to fit directly onto the distribution network, the GridKey system provides a cost effective near real-time monitoring solution.

GridKey is a family of substation monitoring systems that can be fitted to the feeders of an LV, or MV, substation, typically without interrupting supply to customers.

It provides continuous remote monitoring of the substations, as well as timely warnings, status and loading information.

As a result Electrical Utilities/Distribution Network Operators (DNOs) experience reduced network maintenance costs and significantly increased knowledge of the state of their LV/MV grid.

GridKey is a purpose-designed, live-retrofit, compact, continuous monitoring solution suitable for substations. GridKey provides DNOs with the information necessary to drive LV and MV network planning and financial decisions.

Why is monitoring needed?

The use of electrical networks is changing, patterns of use by consumers are changing together with the introduction of low carbon technologies such as intermittent local generation (for example PV panels) and electric vehicles are accelerating the rate of change. In addition the global rise in the cost of electricity tends to increase the amount of energy theft from the network. In order to effectively manage these networks, it is first necessary to understand how they are operating. Historically this has been done by modelling the network and taking intermittent readings of maximum demand recorded but this only provides a general guide – to maximise the performance of the network, a much better measure is required – this is exactly what GridKey was designed to provide.

The business case for monitoring

There are four areas of actionable information provided by GridKey:

- **Faults** – diagnosing and fixing faults as quickly and efficiently as possible gets consumers back on power quicker minimising labour and material costs for the distribution operator as well as minimising any fines or other payments levied for customer power interruptions. Work is being carried out by GridKey on certain types of fault to predict where and when these faults will occur allowing preventative maintenance to take place
- **Losses** – two types of losses are present: technical and theft. Technical losses are the result of assets, typically transformers and cables getting warm, and are caused by load and harmonic content. Balancing phase loads and minimising harmonic distortion reduce these losses. Theft detection is possible both through the combination of domestic and commercial meter data with GridKey data and also through the detection of certain load profiles
- **Power quality** – meeting the quality standards for supply of electricity to consumers is a statutory requirement: monitoring provides details of voltage profiles including effects such as sag and swell as well as harmonic content
- **Planning** – maximising the life on the network, as well as planning replacement and reinforcement of the assets, is essential to managing capital funding spend. This is only possible by understanding the detailed load and voltage profiles of these assets and then analysing this to determine what actions are required

Low voltage monitoring

GridKey produces three systems, known as the MCU520 (Low Voltage, MCU520 (Medium Voltage) and the MCU318. Each of these communicates directly with the cloud based GridKey Data Centre which stores and then analyses the data received to provide the actionable information detailed above.

Each of the systems consists of a number of current sensors, which are fitted on each phase of each feeder and together with voltage taps are connected to a Metrology and Communications Unit (MCU). This unit then processes the sensor data, generates and logs substation loading and condition parameters. This data is relayed to the Data Centre, where it is securely stored and analysed and can be accessed graphically via our customer web portal (or incorporated into the operator’s own data networks).

MCU520 (Low Voltage)

The MCU520 measures the currents of the three phase and neutral, on up to 5 feeders. Designed to be easy to retrofit, the unit can be installed without disruption to supply.

The robust construction allows the unit to be IP65 rated, weatherproof for both indoor and outdoor use - not requiring an earth connection.

Primary communication is via a built-in GPRS modem, although alternative external modems can be connected via an additional module.

The system can provide both regular reports which can be remotely selected at rates from 1 minute to 24 hours. In addition the unit calculates and stores high resolution 1 second data reports and these can be transmitted on request as well as being able to provide a series of programmable alarms for over/under voltage and current.

Current sensing is provided by up to 20 Rogowski coil type sensors – using the GridKey developed GridHound sensors create a Class 1 accuracy solution over a range of 4-720A.

Additional modules also provide the ability to connect a variety of additional sensors such as temperature, intruder or flooding and a modification can be provided to allow a “last gasp” communication in the event of complete power loss.

MCU520 (MV Variant)

A modified variant of the standard MCU520 allows the unit to monitor the MV/HV network. The standard MCU520 is powered from the same voltage taps that are used to measure the phase voltages however when measuring the voltage from a VT output, the load of the MCU (typically around 11W) can cause the voltage level to be distorted.

There are two modifications carried out to the unit to allow it to measure MV. Firstly, to separate the power supply for the unit from the voltage measurement taps allowing it to be powered from a separate power source and secondly, to allow the unit to accept current sensor inputs from either Rogowski sensors or CTs with an external ballast resistor.

Metrology

Measurement Standards	EN 62053-21 Class 1 for active energy EN 62053-23 Class 2 for reactive energy EN 60044-8 Class 1 for rms current
Electrical safety standards	EN 61010-1: 2010, EN 61010-2-030: 2010
Over voltage	300 V rms Category IV. pollution degree 3
Current measurement range	Accurate up to 720 A a.c. per feeder phase No damage at any over-current condition
Operating voltage and measurement range	230V AC + 15%. -20% rms Phase to Neutral
Line frequency	50Hz (nominal)

Protection, Environmental & Compatibility

IP Rating	IP65
Electromagnetic compatibility	EN 61000-6-2 immunity EN 61000-6-4 Emissions
Surge protection	EN 61000 6 kV
Operating temperature range	- 20°C to 55°C (<93% RH, non-condensing)
Storage temperature range	- 25°C to 70°C
Altitude	Up to 2000m
Last Gasp Power Supply	Optional Module Available

Mechanical

Size (h x w x d)	458 x 285 x 109 (with anti-tamper cover fitted)
Weight	3.25 kg
IP category	EN 60529 IP65
Impact	EN 62262 IK06
Power	Power from any phase 9 W typical, 15 W maximum (GPRS enabled)
Communications interfaces *Future expansion via the Auxiliary port	GSM/GPRS quad band 850/900/1800/1900 MHz Any network (SIM can be provided by customer) LV TTL Serial – rates up to 1 Mbd Alternative Interface port (RS232, Modbus, Ethernet, DNP3, etc)*

Data Reporting/Storage

High resolution data	1 Second data available on request from unit
Data reporting period	1 minute, 10 minute, 30 minute

MCU318

Designed to be an entry level system, the MCU measures three phase, only, on up to 6 ways and then synthesises the neutral current.

Quick and safe to connect, it can be retrofitted without the need for interruption, and does not need an earth connection.

The system is weather-resistant meeting IP54 using a series of foam gaskets.

Primary communications are through it's very sensitive GPRS modem making the MCU318 perfect for applications that face network challenges, although future developments will allow both Ethernet and RS485 communications as well.

Regular data reports are available and when used with the SlimSensor current sensor provide Class 2 accuracy between 4-720A. At any point in operation, this data reporting and alert messaging settings (for each MCU) can be individually re-configured remotely via its network interface. The operator can select the MCU measurement reporting interval from 1 minute, 10 minute or 30 minute periods, as needed.

Why Choose the MCU318?

- Easy to fit and compact - Custom designed for monitoring LV substations
- Robust and durable
- No calibration or maintenance
- Class 2 metering accuracy
- Weather resistant to IP54
- Comprehensive reporting of substation feeders
- 2 year, extendable, warranty
- 2.5G, GSM/GPRS Mobile Data transfer between unit and datacentre

Metrology

Measurement Standards	Class 2 in accordance with EN 62053-21
Electrical safety standards	EN 61010-1: 2010, with corrigendum May 2011 EN 61010-2-030: 2010
Over voltage	300 V rms Category IV. pollution degree 3
Current measurement range	Accurate up to 720 A AC per feeder phase No damage at any over-current condition
Operating voltage and measurement range	230V AC + 15%. -20% rms Phase to Neutral
Line frequency	50Hz (nominal)

Protection, Environmental & Compatibility

IP Rating	IP54
Electromagnetic compatibility	EN 61000-6-2 immunity EN 61000-6-4 Emissions
Surge protection	IEC61000 6kV
Operating temperature range	- 20°C to 55°C (<93% RH, non-condensing)
Storage temperature range	- 25°C to 70°C
Altitude	Up to 2000m

Mechanical

Size (h x w x d)	300mm x 245mm x 80mm
Weight	1.35 kg
IP category	IP54 IEC 60529
Impact	EN 62262 IK06
Power	Power from single phase only, 6W typical, 11W maximum (GPRS enabled)
Communications interfaces	GSM/GPRS quad band 850/900/1800/1900 MHz Any network SIM can be provided by customer

SlimSensor and GridHound

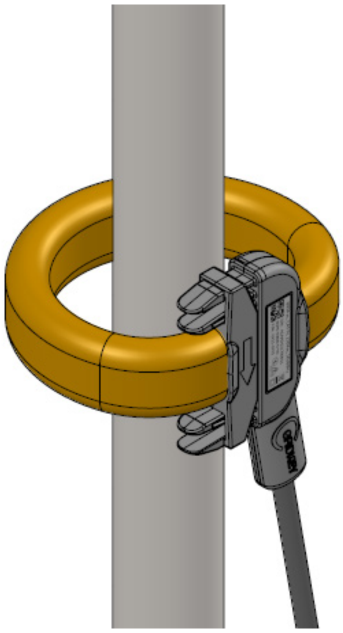
The GridKey system includes a family of high accuracy Rogowski current Sensors that are quick and easy to install without the need to disconnect power.

With the Metrology and Communications Unit (MCU) the sensors form part of the innovative GridKey Low Voltage Substation Monitoring System. GridKey revolutionises substation monitoring, providing continuous real time data on all feeder cables. Designed to connect LV monitoring to the Smart Grid.

GridKey sensors are rugged enough to survive 10 years of continuous use indoors or outdoors (IP65) and provide up to Class 1 metrology accuracy. With a unique footprint suitable for installation in most substation locations.

GridHound sensors are rigid, incorporating a removable gate to allow retrofit to existing cables. These sensors are sized for 300mm^2 wavecon cable. When used with the MCU520 GridHound offers Class 1 monitoring accuracy, in 3m, 5m or 10m cable lengths.

The GridKey SlimSensor is the most accurate flexible current sensor of its type and is sized for cables up to 50mm in diameter, but offers a semi-fliexible solution, coming in 2m, 4m and 6m. Offering Class 2 accuracy with the MCU318.



Why Choose the GridKey current sensors?

- Quick and easy to fit – one-handed installation on tightly packed cables
- Designed for retrofit and live fit
- Low cost of installation and ownership – no calibration, no maintenance required
- Most accurate flexible current sensor; not position sensitive, no cross coupling
- Robust, durable – designed for 10 years continuous indoor or outdoor life (IP65)
- Monitor all feeder cables simultaneously: Measure to manage a smarter grid

Metrology

Measurement Standards	IEC Standard 60044-8
Electrical safety standards	BS EN 61010-1: 2001, BS EN 61010-2-032: 2002
Sensor Type	Type B sensor as defined in BS EN 61010-2-032:2002, Category IV, Pollution degree 3
Accuracy Class	Class 1 (when used with the MCU520), Class 2 (when used with the MCU318)
Rated current	600A
Maximum current	2000A
Output Strength	150mV AC at rated current
Line Frequency	50Hz

Protection, Environmental & Compatibility

Surge protection	IEC61000 6kV
Operating temperature range	- 20°C to 55°C (<93% RH, non-condensing)
Storage temperature range	- 25°C to 70°C
Altitude	Up to 2000m

Mechanical

Minimum required clearance between conductors	14mm
Cable Length	2 m, 4 m, 6 m
Aperture	50mm maximum conductor diameter
Weight	N/A
IP category	IP65 IEC 60529

GridKey Data Management

AWS based system

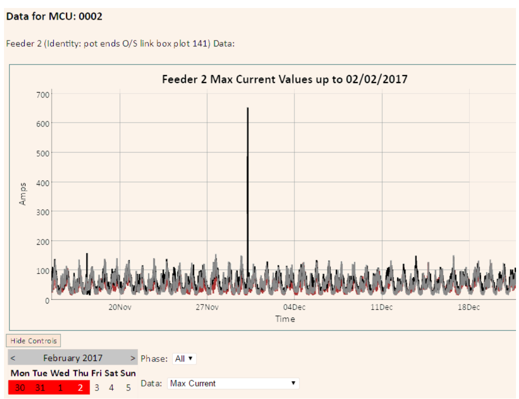
- Offers peace of mind, with 99.999% durability and reliability
- Market leading cloud storage in state of the art facilities
- Encrypted and protected

GridKey Customer Portal

- In browser access for laptops, desktops and Microsoft Surface computers
- Access your data from any location, using any device
- Fully supported and secured log in details for users
- Easily access and interrogate your data, set user permissions and much more...

GridKey Analytics

Future development will allow the user to:



- Choose from a number of analytic package options including; baseline, planning and faults
- The baseline package offers data access and interrogation capabilities
- Planning adds the remote device manager, allowing you to configure and customise your units in the field, or from a single control hub - individually or en masse
- Faults offers the most complete package, allowing for the user to choose from options including: Identification of pecking faults, distance to fault and much more...

Email: info@gridkey.co.uk
Product info: www.gridkey.co.uk