Project Code/Version No: SSET207/01

Low Carbon Networks Fund
Full Submission Pro-forma
Section 1: Project Summary

1.1 Project Title:

Low Energy Automated Networks (LEAN) / Public

1.2 Funding DNO:

Southern Electric Power Distribution plc (SEPD)

1.3 Project Summary:

Southern Electric Power Distribution proposes to demonstrate and deploy the Low Energy Automated Networks (LEAN) solution. This consists of two methods to reduce electrical losses on the 33kV/11kV networks. Approximately 6% of electricity generated is lost each year in the GB distribution network, incurring costs in the region of £1bn to customers. Most of these losses occur within transformer and lower voltage circuit operation.

SEPD will trial two methods to reduce losses. The Transformer Auto Stop Start method will switch off one in a pair of transformers in selected substations to reduce fixed losses. The Alternative Network Topology method will be deployed alongside method one where appropriate, to further reduce losses and maintain network supply integrity. These methods could save over 31,000MWh of electricity over 45 years, worth over £40m to GB customers. This equates to savings of 6,421 tonnes of CO_2.

This type of trial has never been deployed in GB or overseas and poses an element of risk, which may deter DNOs from integrating LEAN into business as usual activities. However, the methods offer worthy benefits if the solution is proven. For this reason, the LEAN project is ideally suited to the aims of the Low Carbon Network Fund.

Knowledge capture and dissemination are key to the successful integration of the LEAN solution into GB DNOs' business as usual activities. The project therefore incorporates extensive knowledge capture and includes the launch of an innovative Network Losses Decision Tool.

1.4 Funding

1.4.1 Second Tier Funding Request (£k): £2,670

1.4.2 DNO Compulsory Contribution (£k): £307

1.4.3 DNO Extra Contribution (£k): n/a

1.4.4 External Funding - excluding from NICs (£k): n/a

1.4.5 Total Project cost (£k): £3,068

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1.5 Cross industry ventures: If your Project is one part of a wider cross industry venture please complete the following section. A cross industry venture consists of two or more interlinked Projects with one Project requesting funding from the Low Carbon Networks (LCN) Fund and the other Project(s) applying for funding from the Electricity Network Innovation Competition (NIC) and/or Gas NIC.

1.5.1 Funding requested from the Electricity NIC or Gas NIC (£k, please state which other competition):

1.5.2 Please confirm if the LCN Fund Project could proceed in absence of funding being awarded for the Electricity NIC or Gas NIC Project:

☐ **YES – the Project would proceed in the absence of funding for the interlinked Project**

☐ **NO – the Project would not proceed in the absence of funding for the interlinked Project**

1.6 List of Project Partners, External Funders and Project Supporters:

LEAN is a highly technical project, which requires deployment and demonstration on a live network. For this reason, SEPD's Future Networks team will carry out most of the work, and therefore the project does not require external funders.

If funding is awarded, SEPD will engage with several project partners. Partnerships will include collaboration with transformer specialists to help build knowledge and understanding of the project's effect on asset health. The supply chain will be involved to ensure that any necessary products and services will be available to SEPD and other DNOs for widespread application of the LEAN solution. SEPD will recruit at least one university to assist with specific learning dissemination work.

1.7 Timescale

1.7.1 Project Start Date:	**1.7.2 Project End Date:**
01 January 2015	31 March 2019

1.8 Project Manager Contact Details

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Section 2: Project Description

This section should be between 8 and 10 pages.

To support the reader, Appendix 11 contains details of all external links and sources referenced throughout the main submission document.

2.1. Aims and Objectives

Southern Electric Power Distribution's Low Energy Automated Networks (LEAN) project seeks to deploy and demonstrate innovative methods of reducing electrical losses within the 33kV/11kV distribution network. GB losses currently cost around £1 billion per year and account for 1.5% of all greenhouse gas emissions in the UK. Forecasts show that the transition to a low carbon economy will lead to significant increases in electricity demand and a corresponding rise in losses. Traditionally, DNOs have tried to reduce losses through long-term asset management, replacing end of life transformers with lower loss models.

LEAN seeks to demonstrate new methods that can be applied to existing assets to reduce losses in the shorter term. The principal method for the LEAN project involves the use of a **Transformer Auto Stop Start** mechanism. SEPD will deploy a second method, **Alternative Network Topology**, where appropriate. LEAN builds on learning captured from SEPD's previous LCNF Tier 1 and IFI projects, which are reviewed in Appendix 2.

2.1.1. Problem statements

The impact of electrical losses on customers

Ofgem reports that approximately 6% of the electrical energy generated in the UK is lost within the distribution network each year, worth approximately £1 billion[1]. These losses are factored into settlements between energy suppliers and network operators and are therefore shared by customers through their electricity bills. Loss reduction in the networks will provide corresponding decreases in customers' energy bills.

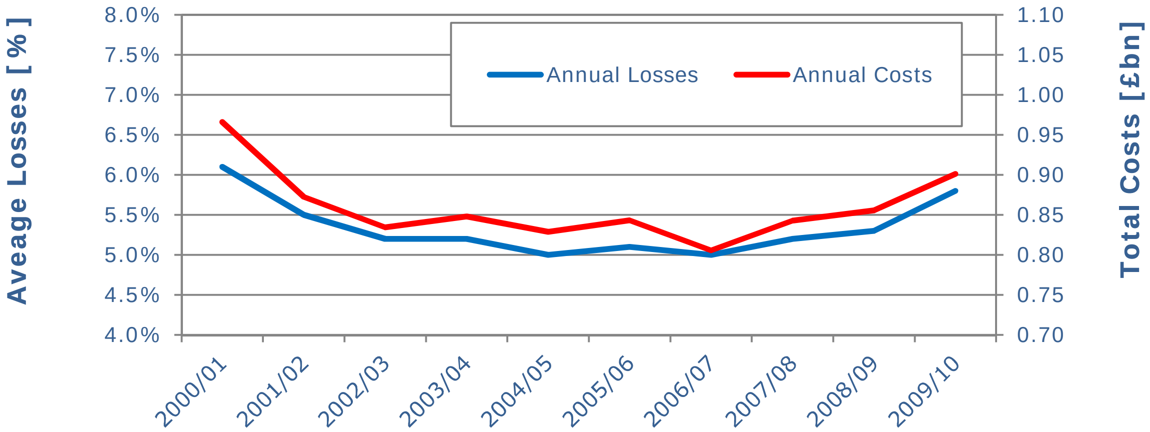

Figure 2.a. Total GB Distribution Network Electrical Losses and Associated Costs

A significant increase in the use of electricity is forecasted as GB moves to a low carbon economy. The increased utilisation of the network will incur an associated rise in losses, the

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cost of which will be borne by customers as Figure 2.a shows.

Southern Electric Power Distribution (SEPD) pro-actively seeks to reduce losses and therefore costs incurred by customers; the LEAN project aims to deploy and demonstrate methods to achieve this. While losses occur throughout every voltage level within the electricity distribution network, they are highest at lower voltage levels, such as 33kV 11kV and LV.

Losses in the GB electricity distribution network

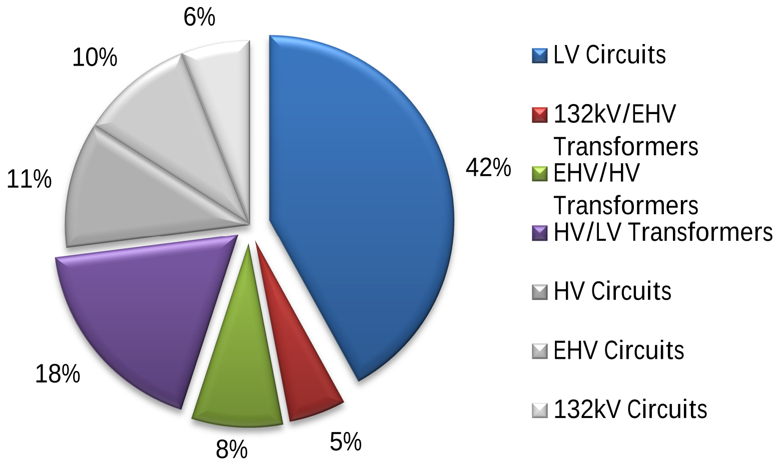

Figure 2.b Distribution network losses breakdown (based on SEPD's Common Distribution Charging Methodology (CDCM) 2014)

Data from SEPD's Common Distribution Charging Methodology 2014 model shows that the highest proportion of distribution losses comes from transformers (31%) and low voltage circuits (42%) as seen in Figure 2.b.

Losses in the GB distribution networks occur for several reasons and are categorised as technical and non-technical in nature. Technical losses consist of 'fixed' losses and 'variable' losses.

Fixed losses (also known as iron losses) arise from the volume of power needed to energise substation transformers. In most substations, two transformers are energised at all times to avoid outages to customers in the event of a fault or maintenance. Generally, they will only run at up to half of their maximum capacity each at any given time. At low loads, fixed losses can be more significant than variable losses.

Variable losses (also referred to as copper losses) will change depending on the load of the substation. When electrical energy passes through transformers and other network components such as cables and wires, it produces heat. This in turn, creates losses. The harder a piece of equipment is worked, the higher losses will generally be.

Networks also incur non-technical losses due to; hot weather heating up overhead lines; imbalances in network configuration caused by different volumes of customer load on several parts of the network and; sub-optimal power factor (power factor describes the relationship between the flow of current and the voltage on lines and cables). In this case, more current needs to be supplied, incurring more losses. Losses are also caused by theft due to connections being made to the network without the DNO's permission.

While some losses are inevitable, SEPD will deploy the LEAN methods to decrease losses where possible, creating a more efficient network and reducing costs to customers. Knowledge dissemination from the LEAN project will also help DNOs to manage current industry challenges, as described in the next section.

Industry challenges

Distribution network operators aim to provide good value to customers while also meeting the simultaneous challenges of (i) GB decarbonisation (ii) compliance with regulatory and legislative guidance and (iii) integrity of supply.

(i) GB decarbonisation: GB has targets to generate 15% of its energy from renewable sources by 2020[2]. As a result, more and more renewable energy is being connected directly to the distribution network. This is known as distributed or embedded generation. Meanwhile, the UK Government's Carbon Plan[3] acknowledges that GB's low carbon future is likely to result in greater electricity demand for transport, heating and industry. The impact of these developments on the distribution network will be significant; demand will become increasingly diverse and unpredictable, with wider contrasts between peaks and troughs. Networks will need to have enough capacity to cope with high peaks but will be under-utilised at times of very low load. Each of these scenarios leads to higher losses; variable losses will increase during periods of high loads, while fixed losses become more apparent during times of low asset utilisation.

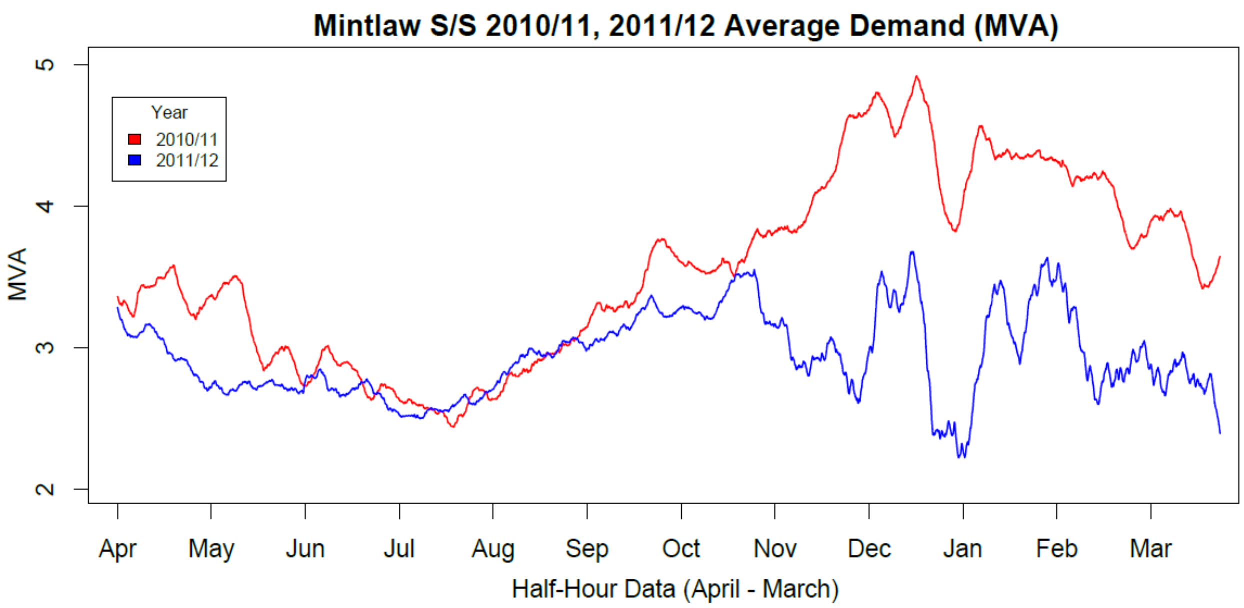

Figure 2.c Comparison of a substation's annual demand profile before and after the connection of distributed generation

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Figure 2.c shows an example of the effect of distributed generation on the network. The graph displays a substation's annual demand profile before and after the connection of distributed generation. The decrease in minimum demand after the connection of renewable distributed generation (shown as the blue line) is clearly visible. The reduction in maximum demand will have a corresponding decrease in transformer utilisation. If the LEAN methods are proven, they can be deployed in this type of situation to reduce losses. This will help accentuate the benefits from distributed generation whilst reducing costs for customers.

(ii) Compliance with regulatory and legislative guidance: DNOs have an obligation to design and operate their networks in such a way as to reduce losses, maintain stable and safe energy supply and provide value for money for electricity customers. If proven and successfully integrated into DNOs' established practices, LEAN will help network operators to meet these requirements.

Further to existing energy network regulations, the EU has recently established the Ecodesign Directive[4], a framework under which manufacturers are obliged to reduce energy consumption and other negative environmental impacts occurring throughout a product's life cycle. Transformers are one of the first types of product targeted by the directive, which advises that lower loss models should replace transformers at the end of their asset life. Complete replacement of current assets will be a relatively slow process. However, if the LEAN solution is proven, it offers an opportunity for DNOs to improve the efficiency of existing power transformers immediately, until they are replaced at the end of their asset life.

(iii) Integrity of supply: DNOs maintain security standard compliance at substation level by keeping two or more transformers energised, sharing the substation load for contingency in the event of a fault or scheduled maintenance. Typically in a dual transformer substation, each transformer works at up to half of its rated capacity. Operating two transformers at all times increases fixed losses and causes two sets of variable losses. The 33kV and 11kV network circuits are (or have the potential to be, through switching) highly interconnected to maintain high levels of resilience. Examples of network diagrams are available in Appendix 3.

When DNOs deploy new transformers, they usually have greater capacity than the current network requires. The purpose of this is to ensure that transformers will have enough capacity to cope with potentially higher loads in future scenarios. Consequently, load factors at these sites during the early years of the transformers' installation may be low in comparison with the transformers' capacity, leading to higher fixed losses.

Conclusion: SEPD acknowledges the challenges facing DNOs and is committed to developing strategies that deliver its obligations. SEPD views these challenges as an opportunity to prove new methods that create efficient, low carbon networks, while providing customers with good value for money and a safe, reliable supply.

2.1.2. The Methods

SEPD proposes the deployment and demonstration of the Low Energy Automated Networks project to reduce losses on the 33kV/11kV network. LEAN will demonstrate a principal method of '**Transformer Auto Stop Start'**. A second method, **'Alternative Network Topology'** will supplement method one if deemed appropriate, to further reduce losses and mitigate risk of customer interruptions.

As described on page four, many distribution substations operate a dual transformer system. While both transformers are not generally worked to their full capacity, they remain energised at all times, so that in the event of one transformer experiencing a fault, integrity of supply is kept intact. LEAN challenges this approach.

Method One – the Transformer Auto Stop Start system (TASS)

The Transformer Auto Stop Start system is a technical solution, which will be applied to selected 33kV/11kV primary substations that have dual transformers.

SEPD will deploy the Transformer Auto Stop Start system to switch one in a pair of transformers off when load is low enough to reduce fixed losses. Page 4 describes both fixed and variable losses, which can be compared to the fuel lost by a car in various stages of operation:

- The **fixed losses** in a transformer represent the **minimum electrical energy that is spent to keep the transformer energised**; this is like a car engine that needs fuel to idle when stationary.
- **Variable losses** in a transformer on the other hand, represent the **electrical energy lost to supply a load**. Variable losses in a transformer are proportional to the square of applied electrical load; this is like a car that burns more fuel when in motion.
- When **low or no electrical load** is applied (similar to a car at low speeds or waiting with engine left ON), **fixed losses can be more significant than variable losses** (similar to driving at less than optimum speed).

The Transformer Auto Stop Start system applied on a transformer is similar to an automatic stop-start mechanism installed in most modern cars.

- When the applied substation electrical load falls below an optimum OFF threshold value, the Auto Stop Start system turns OFF a transformer among the pair at the substation; and vice-versa when the substation's load exceeds the optimum ON threshold.
- The optimum ON and OFF threshold values correlate to the percentage of applied substation load values to ensure that switching the transformers off only happens at times of low load, and to avoid excess switching. Excess transformer switching could affect the asset health and adversely impact on supply quality.

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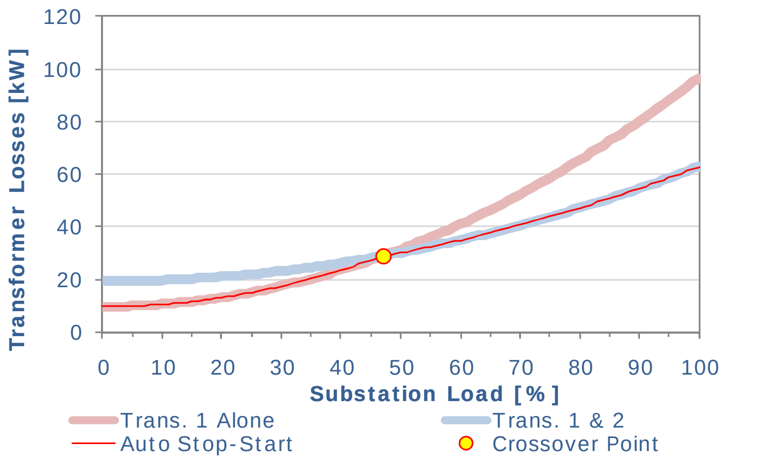

Figure 2.d Simple diagram of Transformer Auto Stop Start system

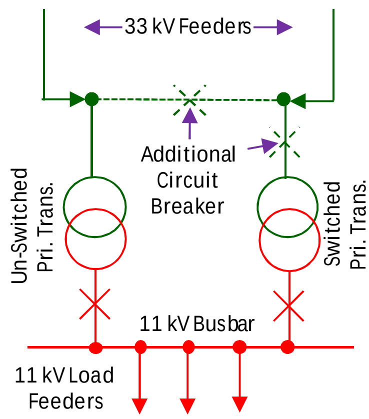

Figure 2.e Primary Substation with Additional Switching Equipment

The **Transformer Auto Stop Start (TASS) system** will be applied to a representative number of dual transformer substations at times of low load to reduce losses. The system can be applied using one or a number of options as shown in Figure 2.f:

TASS Options	What does this involve?	Advantages/Disadvantages
1. Simple remote control of existing switchgear	Switching is done manually, in the network control room or via existing remote control mechanisms.	§ Lower cost option. § Higher risk of supply interruptions and adverse power quality. § May cause higher impact on asset health.
2. Advanced control of existing switchgear	Switching is controlled by use of specific protection equipment. This reduces risk from transformer inrush current.	§ Medium cost option. § Medium risk of supply interruptions and power quality. § May cause some impact on asset health.
3. Deployment of high performance switchgear	Switching is controlled by combination of specific protection equipment and use of advanced switchgear.	§ Higher cost option. § Lower risk of supply interruptions. § May cause lower risk on asset health.

Figure 2.f Table of TASS options and possible impacts

Method 2

The second method to be demonstrated in the LEAN project is **Alternative Network Topology (ANT)**. Note that this is a secondary method; SEPD will deploy this where appropriate to supplement TASS, and to provide risk mitigation against supply interruptions. ANT is a technical method that will implement network meshing of selected 11kV network circuits dependent on network demand. ANT simply “matches” a substation selected for TASS (where one of a pair of transformers may be switched off and one will remain energised) and interconnects it to another substation nearby via the 11kV network. The network is then configured so that, in the case of the remaining energised transformer experiencing a fault, the circuits it feeds will be routed to the second substation, avoiding supply outages. This can be described as ‘meshing’ the substations, or operating them ‘in parallel'.

The Trials

The LEAN project will comprise of three phases. Knowledge dissemination will take place incrementally throughout the project to ensure learning capture is shared. A comprehensive description of the project's programme is available on Appendix 4.

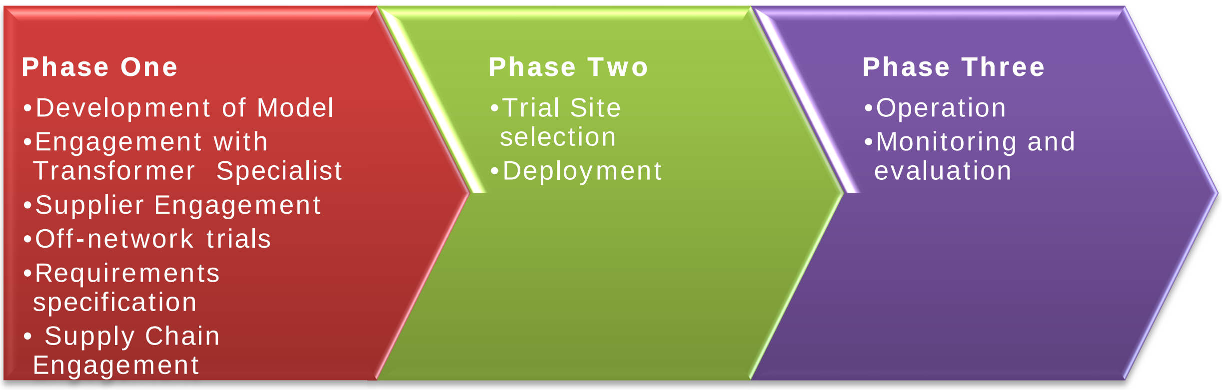

Figure 2.g Phases 1-3 of the LEAN project

Phase One

The first phase of the project consists of the following activities:

(i) Development of loss-reduction model: This activity involves in-depth study and analysis to investigate actual load profiles across the network. Initial selection of substations and circuits for LEAN deployment will be made to ensure that the collective group is representative of the GB electricity distribution network; this maximises potential for widespread replication should the LEAN methods be proved.

(ii) Engagement with a specialist: In-depth investigation and consultation with a transformer specialist will include validation of initial assumptions, consideration of the impact LEAN may have on asset health, the identification of risks and appropriate mitigations and advice on measurement and monitoring strategies. This is to capture early knowledge surrounding potential impacts, e.g. LEAN deployment's effect on asset life and/or performance and unplanned interruptions.

(iii) Supplier engagement: SEPD will engage with manufacturers and suppliers of its existing asset portfolio to make further validation of assumptions made, and to evaluate the impact on any potential impact on asset life, test strategies and risks.

(iv) Off-network trials: Pre-deployment testing will be carried out on a transformer that is not currently connected to the distribution network. This allows the project team to capture knowledge concerning the transformer's reaction to LEAN deployment.

(v) Requirements specification: A functional requirement for necessary equipment will be developed and made available to the supply chain. This is to ensure that (i) the cost assumptions for the project are correct and (ii) there is a robust and secure supply chain available to support a widespread rollout of LEAN.

The work undertaken in Phase 1 of the LEAN project will serve to establish a clearer and more robust understanding of the benefits, costs and risks associated with LEAN application. This will be developed through; a combination of further detailed modelling using actual SEPD transformer data; actual load duration curves; engagement with transformer specialists and manufacturers; and development of a detailed requirements specification for the additional equipment required to deploy LEAN. Throughout this process, SEPD will engage with other DNOs to seek their insight and involvement. This engagement has already commenced with Electricity North West, which has a related Tier 1 project (Combined On-Line Transformer Monitoring).

At the end of Phase 1 the project's benefit case will be re-evaluated. The project will only proceed if the trials can demonstrate clear benefits for customers without causing financial detriment to DNOs. LEAN has been designed to provide benefits to customers i.e. there are no financial benefits for DNOs. During Phase 1, evaluation will be carried out to ensure that LEAN does create barriers or financial losses that would make deployment unattractive to DNOs. Further details of the work planned for Phase 1 and the evaluation process are included in Appendix 12.

At the end of this phase, SEPD will have validated the underlying assumptions, allowing the team to confirm that the project offers sufficient value and warrants deployment. If at this point SEPD decide that it would be prudent to halt the project, the correct procedures will be instigated as outlined in governance and project direction documentation.

Phase Two

The second phase of LEAN is concerned with validation of the model i.e. actual deployment and operation, and is comprised of the following activities:

(i) Final site selection: A number of primary substations will be selected for LEAN deployment (TASS options 1, 2 and 3, and where appropriate, ANT). The substations will be representative of SEPD's and GB's distribution network scenarios, but will also be selected to ensure that there is minimal risk of supply interruptions.

(ii) Deployment and demonstration: The LEAN methods will be applied over a two-year period.

Phase 3

(i) Operation and monitoring: The selected transformers will be monitored throughout two years of operation, to capture learning related to the operation of LEAN in real life scenarios. The types of monitoring will depend on the type of equipment used and on which blend of TASS and ANT has been deployed.

The Solution

The solution from the project will be a validated network loss reduction model. This model will identify the locations where the LEAN method can be successfully applied. Learning outputs are described on page 11 (Figure 2.h)

Problem	Solution
Impact of electrical losses on customers	LEAN's loss reduction methods will decrease the costs associated with distribution within customers' electricity bills. The project business case, which identifies benefits for customers, is discussed in Section 3 of this document.
Losses in the GB electricity distribution network	§ Quantify the level of losses, which can be reduced by using the TASS and ANT methods in a variety of scenarios. § Understand the impact that the various combinations of LEAN methods have on asset health, life and quality. § Information regarding effects on customer supply and reliability. § Improve the management and efficiency of the elements of the network that incur highest losses. § Provide learning to inform network equipment manufacturers to assist the creation of a robust supply chain.
Industry challenges	§ Decarbonisation – LEAN will provide DNOs with tools to improve the management of future energy scenarios, which can contribute to losses. § Compliance with legislation – LEAN's methods to reduce losses will help DNOs to meet the new licence condition to ensure that losses are 'as low as reasonably practical'. § Integrity of supply – LEAN's ANT method will reconfigure the network to maintain integrity of supply.

Figure 2.h Solutions facilitated by LEAN

2.2. Technical Description of Project

The LEAN method uses the knowledge gained in two of SEPD's IFI projects; these are the Isle of Wight Network Losses Reduction Study and the Advanced Radio Controls project. Appendix 2 offers a detailed review of these studies. SEPD will select sites to participate in the LEAN project; each of the sites will be analysed to select which TASS option (or blend of options) should be applied, and whether ANT is appropriate for deployment:

Option 1: This involves deployment of remote operator-based, simple TASS control of a substation transformer, which is switched using existing switchgear. This is a low cost trial, which is suitable for sites where a transformer among the substation pair can be de-energised for longer durations.

Option 2: This involves deployment of advanced TASS local control on a transformer among the substation pair. Option 2 employs inrush reduction mitigation via advanced control using existing switchgear. This method may be appropriate where a transformer is de-energised and re-energised frequently, and where transformer energisation related inrush currents might interfere with supply integrity.

Option 3: This consists of deployment of advanced substation TASS local control on a transformer among the substation pair, and employs higher performance switchgear. This method may be appropriate where a substation transformer is de-energised and re-energised frequently, the network is known to have poor reliability, and transformer energisation-related inrush currents may interfere with supply integrity, power quality (such as voltage flicker) or asset condition. Use of high-performance switchgear with transformer inrush mitigation controllers will be considered.

Alternative Network Topology: This will be applied to complement the TASS deployments in order to maintain network security. In the event of a network fault, a feeder switchgear device or a centralised, control level algorithm will quickly reconfigure the network isolating the fault, while minimising the impact on customers and maintaining supply.

The methods proposed by the LEAN project have not been tested or deployed before in the GB or elsewhere in the world; the associated risks with these methods will require thorough understanding, and adequate risk and mitigation measures in place, before deployment. For this reason, deployment will only take place after extensive desktop analysis, expert input and supplier engagement.

2.3 Description of Trials

The project has three distinct phases with knowledge captured and disseminated incrementally. The project has robust working practice and knowledge dissemination as key priorities:

- Site selection uses clearly defined parameters to ensure minimal impact on customer supply.
- Sites are selected because of their potential for learning and benefits to be captured.
- Evaluation at each stage will include benchmarking against the performance of established methods used by SEPD.
- Extra monitoring will be installed in order to consolidate learning.
- The project will follow SEPD's rigorous governance procedures for good management.

2.4. Changes since the initial screening process

Method one's title is Transformer Auto Stop Start; this is modified to clarify that this method is applied to transformers only. The project team has continued to develop the LEAN concept since submission of the ISP. This has enabled clearer identification of the issues and problems that LEAN will help to address. As a result, the requested funding has decreased since the original ISP was submitted.

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Section 3: Project Business Case

This section should be between 3 and 6 pages.

3.1 Business Case Context

Southern Electric Power Distribution's core purpose is to provide the energy people need in a reliable and sustainable way. As a licensed electricity distribution operator, SEPD has statutory duties, which are set out in the Electricity Act 1989. Principal duties are to (i) develop and maintain an efficient, co-ordinated and economical system of electricity distribution and (ii) facilitate competition in the supply and generation of electricity.

Losses at all stages of the electricity supply chain i.e. generation, distribution and transmission, are included in a settlement system and these costs are factored into customers' energy bills. Therefore, SEPD is keen to minimise network operational costs through loss reduction while maintaining a resilient and secure supply of energy; the LEAN project will focus on this.

Additionally, the European Commission has recently introduced Directive 2009/125/EC[4] regarding the design of electrical equipment. This obliges DNOs to procure and install lower loss models to replace old transformers at the end of their asset life, and for new substation projects. These transformers tend to be more expensive and potentially larger than their traditional equivalents.

3.2 Integration with the SSEPD Business Plan

Ofgem recognises the importance of minimising network losses and has given this issue a renewed focus in for the RIIO-ED1 period. DNOs must pro-actively work to manage losses. New parameters to help DNOs with loss management include a new licence obligation to keep losses as low as reasonably possible. Ofgem have also made it mandatory for DNOS to publish an annual Losses Strategy Statement, in addition to implementing annual audits on loss activities. A key focus will include the sharing of best working practice between DNOs and of course, the current annual reporting requirements will continue. SEPD's proposals to meet these requirements are described in the RIIO ED1 Business Plan Update (March 2014)[5] and can be summarised as follows:

- Continue current, successful asset replacement programme to deploy lower loss equipment, and with optimal configuration of the network.
- Continue with programme of implementing a range of technologies designed to reduce losses as part of normal business processes on the lower voltage networks (11kV and below).
- Use innovation to increase the range of technologies available for standard implementation.
- Improve understanding of the energy use of customers and work with customers to reduce their overall energy use, especially at peak times, taking advantage of smart metering as part of this process.
- Use new sources of data to create better models that allow analysis and losses tracking, and target loss reduction.

- Work with Electricity Supply Licensees to detect and prevent fraudulent energy use. Fully utilise the data to address omissions, under reporting and abuses

The LEAN project strongly aligns with the 'Innovation' objective by demonstrating a novel method of achieving a significant reduction in losses beyond that which would be included in any 'business as usual' approach. Importantly, the project will look to demonstrate that loss reduction is achievable with no adverse effect on supply quality or asset condition.

3.3 Motivation for the LEAN Project

As indicated above, there are strong policy and regulatory drivers for SEPD to reduce losses. Ofgem's 2010 factsheet[1] reports that approximately 6% of the energy generated is lost in the distribution system as electrical losses; this costs in the region of £1 billion each year.

The move to a low carbon economy will see a growth and increased variability in demand in the future due to the increased electrification of heat and transport, which in turn will lead to a corresponding rise in network losses.

There is also an ever-increasing volume of distributed generation requiring connection to the network. In combination, these factors will result in a move away from the current, well-understood and predictable demand profiles, to a future where network demand profiles are increasingly intermittent and unpredictable. DNOs will require new and innovative methods to meet these new challenges whilst meeting the requirement to minimise losses as much as reasonably practicable. The LEAN project proposes to achieve this by "de-energising" one of a pair of primary substation transformers to reduce the fixed losses.

As discussed in Section 2, one of the impacts of distributed generation will be a reduction of minimum demand at primary substations. This type of situation will only increase as more distributed generation is connected to the system. However, there is no corresponding decrease in peak demand, so DNOs must retain the existing installed plant capacity to minimise the risk of customer interruptions.

SEPD carried out an IFI project that studied the impact of losses on the Isle of Wight network; these results are summarised in Appendix 2 and have guided SEPD's approach to the LEAN project.

3.4 Applicability of the LEAN Methods

A typical 33/11kV substation is arranged with a pair of transformers that are each capable of supplying the total firm capacity. Both of these transformers are maintained energised at all times. The equation for losses from these two transformers are can be described as:

> **Total Losses = (fixed losses for both transformers) + (variable losses for both transformers).**

The total losses for a dual transformer substation are shown for a range of load factors in the graph below (red line), along with the losses for a single transformer (green line). This graph illustrates that, for many 33/11kV substations, it is more economical to operate a single transformer when the load is below about 50% of its capacity rating.

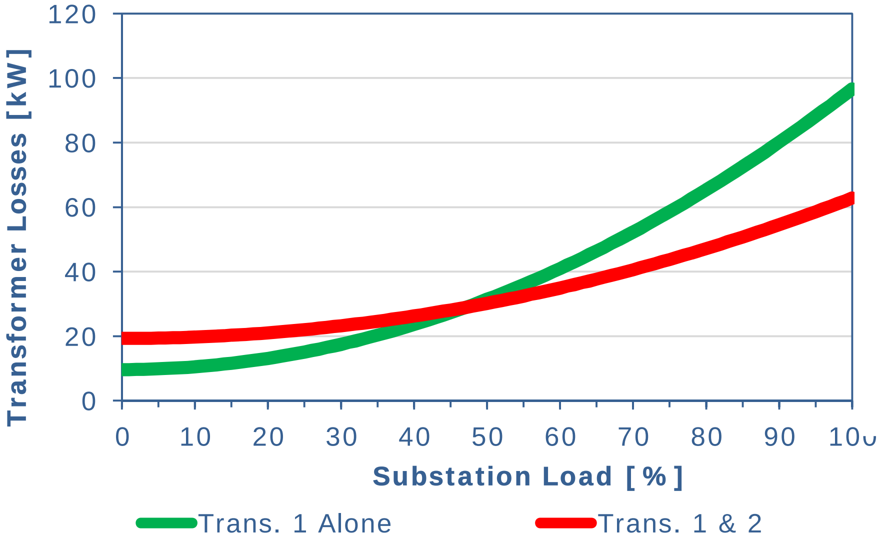

Figure 3.b Graph depicting loss performance according load factors

SEPD carried out analysis on the current loading of each of its primary substations, to evaluate the number of transformers operating at less than 50% load factor. The results are shown in Figure 3.c below.

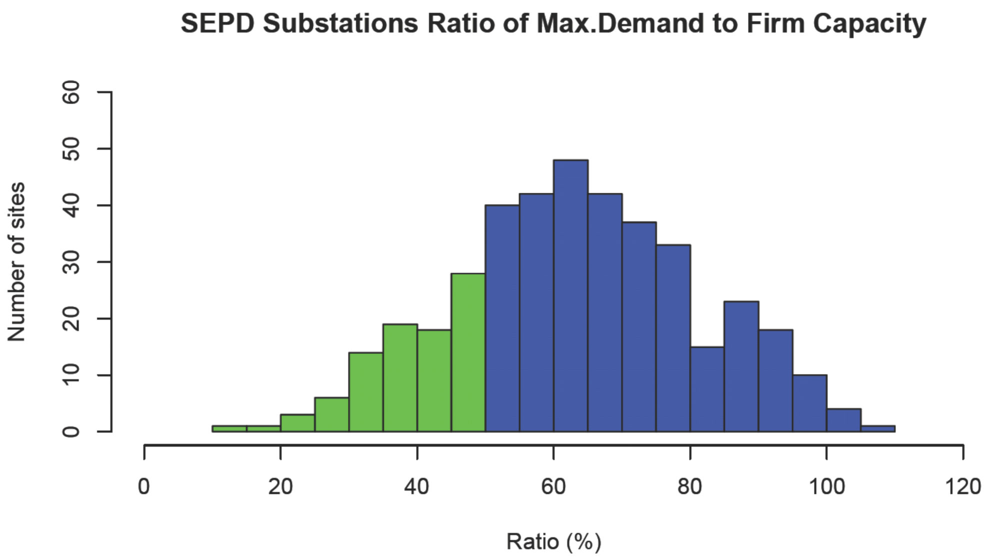

Figure 3.c Graph depicting varying load factor in primary substations

These periods of low load at primary substations will become increasingly common due to the connection of distributed generation. Closer analysis of the demand profiles suggest that even sites with higher load factors may have periods of lower demand, which would justify de-energising one transformer to reduce losses. The graph below was prepared to model a dual-transformer substation with a load factor of 30%. It shows the losses for single and dual transformer operation during each half-hour of a year's load. There are many periods when a single transformer is the lower loss option (where the green trace is below the red trace).

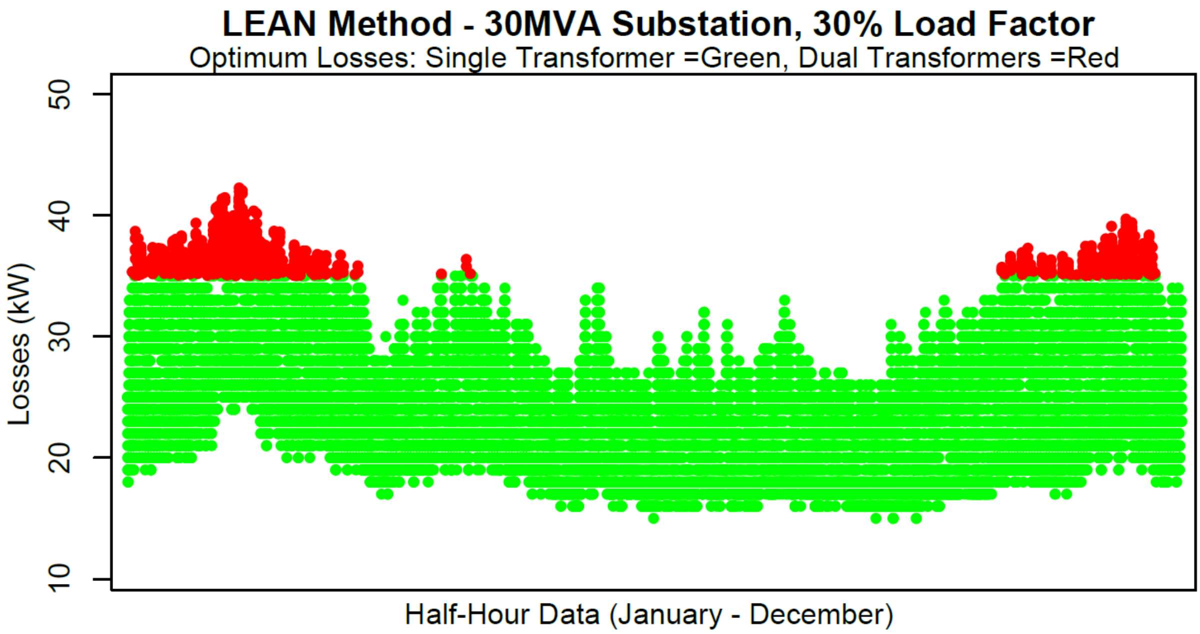

Figure 3.d Graph depicting a losses comparison between single (green) and dual transformer (red) operation

From the initial analysis carried out by SEPD, 30% to 40% of primary substation sites have a load factor of less than 50%. Extrapolation of these results to GB level indicates potential to target a significant number of sites. To prepare this submission, the volume of losses that could be saved was estimated by S&C consultancy, using the following process:

- The half-hourly demand profile from the test site used in the Isle of Wight IFI project was selected as a basis;
- This demand profile was extrapolated for all of SEPD substations based on the maximum and minimum demand figures identified in SEPD's Long-term Development Statement[6].
- From this, it was possible to identify the number of hours where it would be worthwhile to de-energise one of the two transformers.
- The avoided losses were calculated using commissioning records for the individual transformers.

3.5 Project Benefits

Cost of Lost Energy: The project's loss savings estimations are based on the same methodology used in the recent RIIO ED1 submission. In this process, the value of lost energy was identified as £48.42 per MWh. If the typical figure of 90MWh per annum is assumed, then the energy saved each year has an approximate annual value of £4,500 and, based on an unchanged load factor, the discounted present value over 45 years would be approximately £126,000 per site.

Method Cost: This project will investigate the opportunity to de-energise transformers by a variety of means including manual operation, remote control via existing switchgear and automatic control using high-performance switchgear. The estimated method cost is described below:

§ **Option 1:** De-energise transformers via remote control of existing switchgear with additional 11kV network automation if appropriate. The anticipated cost of this option has been estimated at [redacted] per installation.

§ **Option 2:** De-energise transformers using remote control including advanced local control equipment to ameliorate any switching surges, or inrush currents. The anticipated cost of this option has been estimated at [redacted] per installation.

§ **Option 3:** De-energise transformers using remote control with high-performance switchgear to reduce inrush currents repeatedly. The anticipated cost of this option has been estimated at [redacted] per installation.

Financial Benefits from LEAN:

Using a generic load profile and the value of £48.42 per MWh, the application potential of the LEAN solution was tested firstly across SEPD's portfolio of primary substations. These results were then extrapolated to GB level. These results are summarised in Figure 3.e, below, and further information can be found in Appendices 5 and 12 , which provides further information for the business case and the Stage Gate at the end of Phase 1.

GB Wide Cost Benefit Assessment	Option 1	Option 2	Option 3
GB total number of sites		4800	
Percentage of sites viable for LEAN	30%	24%	5%
GB sites for Option Modifications - pro rata	1416	1166	219
Total Investment [£]	[redacted]	[redacted]	[redacted]
Gross Benefit [£]	£65,551,040	£61,743,388	£23,002,922
45-Year Losses Savings [MWh]	1,521,079	1,432,732	533,768
45-Year CO2 Savings [ktCO_2e]	306,773	288,948	107,641
45-Year Savings NPV [£]	**£49,056,635**	**£46,207,091**	**£17,214,768**

Figure 3.e Table depicting benefits of LEAN extrapolation to GB-wide distribution system

Figure 3.e describes the energy, cost and carbon savings that each of the TASS options may provide. Note that these options are not summative; the analysis carried out on SEPD's portfolio only selected sites where net cost savings were higher than the cost of deploying one of the TASS options, which gave a figure of 136 (30%) of substations suitable for TASS deployment (Option 1). Of this 30%, extra analysis was carried out to see how many of

these 136 substations still showed net financial benefits if Options 2 or 3 were to be deployed. For Option 2, this amounted to 112 substations in total, and for Option 3, this amounted to 21. As Options 1 and 2 appear to demonstrate greater potential for widespread application, they will be tested in a representative number of sites during the LEAN project. The third, more expensive option will be trialled on a limited basis where deployment would present clear value for money only.

The benefits shown in Figure 3.e are based on the **current** demand profiles for these primary substations; note that the estimates do not take future changes in customer behaviour into account. Nevertheless, future customer demand is very likely to change as a direct result of participation in green initiatives such as solar PV and other embedded generation technologies. This will result in increased intermittency of demand on the distribution network, and reduced asset utilisation.

While the methods described seem straightforward in their application, there are risks involved. The repeated de-energisation of large power transformers is untried as a means of reducing network losses and it is important to make use of Tier 2 funding to prove the effectiveness of these methods over a range of transformer types and network configurations.

It will be important to demonstrate that the project has identified any risk to transformer and other asset health due to magnetising inrush currents. Option 3 will demonstrate whether modern high-performance switchgear can resolve this issue in a cost-effective manner.

In order to maintain quality of supply the project will evaluate the use of ANT network parallels between TASS-applied primary substations. Where practical, this project will demonstrate how to enable this ‘paralleling’ with minimal changes to existing HV feeder circuit breakers and associated protection schemes.

Importantly, all of the savings identified from LEAN will benefit distribution customers directly.

Environmental Benefits from LEAN

The energy saving achieved by LEAN will have important environmental benefits. The losses avoided will reduce the volume of energy generation required to supply the same level of demand as before. Figure 3.e shows the significant carbon benefits may be realised from the project. Appendix 5 describes carbon savings calculations in detail.

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Section 4: Evaluation Criteria

This section should be between 8 and 10 pages.

4.a Accelerates the development of low carbon energy sector & has the potential to deliver net financial benefits to future and/or existing customers

SEPD's LEAN project will conclude in 2018, the same year as the third budget phase of the Department of Energy and Climate Change's (DECC) Carbon Plan[3] begins. The third carbon budget, which runs from 2018-2022, requires a reduction of 35% in carbon emissions compared to base levels set in 2009.

The LEAN project will help make significant contributions to the development of a low carbon sector. Early analysis extrapolated across GB indicates that the methods will deliver a reduction in annual network losses of up to 31,838MWh, which is equivalent to 6,421 tonnes of CO_2. Please note that, as per the business case, the second method of Alternative Network Topology is complementary to the first method (Transformer Auto Stop Start system). ANT will only be deployed when appropriate, to maintain network integrity. For this reason, carbon and cost savings are accounted for together.

LEAN aligns with the Carbon Plan in several ways:

(i) Ofgem advises that **electrical losses account for 1.5% of the UK's carbon emissions**[1]. This project seeks to deliver a methodology focussed on reducing networks losses, with consequential reduced carbon intensity. If the LEAN solution is successful, it offers DNOs the potential to make tangible contributions to achievement of the third Carbon Plan budget through the direct reduction in electrical losses and associated carbon emissions.

(ii) The Carbon Plan's strategy includes a **focus on increasing energy efficiency**. This includes a product policy that imposes legally binding EU minimum standards of energy-using products. One aspect of this is the new Ecodesign Directive[4]. Transformers are one of the first product types targeted by the Directive; lower loss models must replace older, less efficient models at the end of their asset life. The rate of replacement is around 1% per annum, which means that benefits will be slow to realise.

In comparison, the LEAN solution quickly achieves loss reduction within existing asset portfolios, and will achieve a similar step change in the reduction of annual losses. Early modelling and analysis shows that LEAN may have potential for application to up to 30% of existing primary substations; therefore carbon emission savings will be much quicker to attain than would otherwise be the case, even with the implementation of the Ecodesign Directive. The proven rate of application and benefits of the LEAN methods will depend on the findings of this project.

(iii) The Carbon Plan advises that **electricity demand may significantly increase** by 30% to 60% between now and 2050 because of the electrification of power, heating and transport, the mass rollout of which is estimated to take place from 2020. With increased demand comes increased losses unless network intervention can manage this; application of LEAN methods on a GB-wide basis will ensure that increases in losses are minimised.

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Evaluation Criteria continued

(iv) The Plan's strategy for the **decarbonisation of electricity** requires an "electricity infrastructure that is robust, flexible and able to respond to future demand for renewable energy and smart grids/demand-side management." (The Carbon Plan[3], page 101). Rising levels of distributed generation leads to periods of reduced substation utilisation and will increase the opportunity to deploy LEAN. If the LEAN solution is proven, it will help DNOs to manage the effects that distributed generation connection and other low carbon technologies will have on the network. These methods therefore, aid DNOs to create flexible and dynamic networks of the future.

Importantly, the LEAN methods offer DNOs knowledge and tools that help losses reduction to be delivered more quickly than would be the case with long-term asset replacement, producing immediate carbon and cost savings. These savings can be realised within the third Carbon Plan budget timeframe and beyond.

LEAN has the potential to offer net financial benefits to future and existing customers:

Ofgem's 2010 factsheet[1] reports that approximately 6% of the electrical energy generated is lost in the distribution system as electrical losses; this costs in the region of £1 billion each year. The cost of these losses is ultimately borne by customers. Therefore, any initiative that reduces losses will have a positive effect on customers' bills.

DNOs' traditional approach to reducing losses uses lower loss asset replacement programmes. In general, assets are only replaced at the end of their life, or because of necessary upgrades in response to network changes. This methodology results in a gradual replacement of assets over a prolonged period. While the Ecodesign Directive will help to increase transformer energy efficiency and reduce losses, it may take up to 60 years to achieve its ultimate objective.

In contrast, the LEAN solution provides the opportunity to deploy a new approach that should allow DNOs to achieve a step change in their loss reduction performance. Initial desktop analysis of the SEPD portfolio of primary substations suggests that the solution could be deployed in up to 30% of current installations.

If a typical energy saving of 90MWh per site per annum is assumed, then the energy saved each year has an approximate annual value of £4,500. Based on the current load factor, the discounted present value over 45 years would be approximately £126,000. This is the cost of losses per site, which will be borne by customers if the LEAN approach is **not** implemented.

The method costs identified are based on the widespread adoption of the LEAN methods. Costs associated with LEAN equipment will reduce significantly if the methods are adopted on a widespread basis due to economies of scale in production and a reduced need for monitoring after the method are established.

Based on the analysis identified in the Business Case (as detailed in Section 3), the LEAN solution could be applied in up to 30% of sites and deliver benefits in excess of £40m.

4.b Provides value for money to distribution customers

The learning from the LEAN project will demonstrate a cost-effective means to help meet Ofgem's new licence obligation to 'ensure that losses are as low as reasonably practicable' without consequential risks to customer supply or assets. The level of benefits and learning from the LEAN project offers good value in comparison to the value of funding sought from LCNF's Tier 2 scheme for the following reasons:

(i) SEPD estimates that LEAN deployment across GB could create reductions in losses worth in excess of £40 million, which will benefit GB electricity customers. Current asset management strategies will reduce losses in the long term through the procurement of new, energy-efficient transformers. In contrast, the LEAN solution offers DNOs the ability to reduce losses in a much shorter timescale, which can be translated into cost savings. Section 3 of this document and Appendix 5 discuss cost benefits in more detail.

(ii) LEAN's programme of knowledge capture and dissemination is valuable to other DNOs, which face the same challenges as SEPD in terms of losses management, licence obligations and the requirement to facilitate the country's move to a low carbon economy. LEAN is designed to ensure that learning is optimised at every phase, allowing quick and relevant knowledge to be made available to other DNOs and other relevant stakeholders. The innovative Network Losses Reduction Tool will allow other DNOs to assimilate cost benefits associated with deployment of LEAN on their own networks, saving time and money that would otherwise be used to evaluate ways of reducing losses. Section 4.c and Section 5 cover knowledge dissemination in more detail.

LEAN will be deployed within a range of substations across SEPD's network, which is representative of the overall GB network. This assumption is based on a number of factors:

- SEPD's network consists of both urban and rural areas, and includes a wide range of demand profiles.
- All of the GB networks have been designed to comply with a common set of standards such as P2/6.
- Transformer assets across GB have typically come from a core group of equipment manufacturers and have been designed, built and operated to comply with a similar set of safety, operational and procedural requirements.

Phase 1 incorporates a programme of stakeholder engagement including involvement of other DNOs. At this stage, SEPD will work with these DNOs to ensure that the selected sites can demonstrate the method sufficiently to create investor-level confidence in LEAN deployment. SEPD and Electricity North West have already engaged with a view of sharing information on LEAN and ENW's Combined On-line Monitoring project (an LCNF Tier 1 project). Appendix 12 describes this engagement.

(iii) LEAN project delivery will include appropriate procurement processes to ensure best value for the project. This will include not only procurement of electrical equipment, but also the selection of expert advice and support. These processes will also test the market to ensure that there is a robust enough supply chain to support a widespread roll out of the solution.

The project will comply with SEPD's established procurement processes, which use robust and transparent parameters. New, higher performance switchgear (option 3 of TASS) may only be suitable for use across a smaller proportion of substations therefore a prudent approach will be taken when selecting the type and number of sites upon which to deploy this option.

(iv) The LEAN project is innovative in that the TASS and ANT methods have never been tried within transmission or distribution networks (GB and worldwide). There are various risks associated with this type of loss reduction activity that would deter DNOs from implementing LEAN as part of their business as usual practices. These risks are described in Figure 4.a and are covered in greater detail in the Risk Register (Appendix 6).

Risks associated with LEAN	
Technical risks	Little is known about the effects of increased switching of transformers in terms of asset life and health. In addition, there is scarce information available about the effects of switching of transformers that have been in service for long periods.
	Switching transformers to an energised but non-functional state (similar to a TV's 'standby' mode) is possible, but this will not reduce fixed, or iron, losses and is therefore uneconomical. Full switch-off is necessary to reduce losses but runs a risk of supply interruptions. This is why LEAN's blend of two methods is important; careful site selection and reconfiguration of networks is necessary to maintain supply.
	The variability and increased unpredictability in demand profiles (caused by connection of electric vehicles, demand-side response and microgeneration) are new to GB networks and therefore it has not been possible to conduct this type of demonstration before. SEPD's network contains areas where a wide range of distributed generation is connected and is representative of GB as a whole.
Commercial risks	Previous work on loss reduction carried out by other GB DNOs has shown poor cost-benefits ratios. For this reason, SEPD would prefer to use the protection of LCNF for this project. LCNF allows SEPD to demonstrate the LEAN method within a comprehensive range of scenarios that can be safely deployed to GB networks if proven.
	DNOs do not carry out activities that put customers at risk of supply interruptions. However, LEAN uses careful desktop analysis, site selection and engagement with an expert to minimise risk. SEPD will apply Alternative Network Topology where appropriate to manage network reliability in a pro-active way.

Figure 4.a Table outlining risks associated with loss reduction activities

SEPD explored a range of potential impacts the LEAN approach could incur and considered appropriate mitigation strategies. Further details of the reviews carried out are described in Appendix 7. In addition, SEPD looked at other mechanisms for loss reduction (see Appendix 8), but felt that the level of risk associated with these mechanisms was too high to proceed at this stage.

These factors render the initial deployment of the LEAN methods as high risk in terms of cost, asset and human resources for DNO business as usual processes. LCNF support allows power quality monitoring to be placed at strategic network locations to confirm that there is no significant impact on power quality during transformer switching. Additional attention will be given to any additional switching noise that could cause annoyance to people living near the selected sites.

4.c Generates knowledge that can be shared amongst all DNOs

The delivery of the LEAN project will enable significant learning and the generation of new knowledge from the projects and studies undertaken within it. A full description of the plan to capture and disseminate learning is included in Section 5.

(i) The project has been designed to optimise learning and knowledge within every phase; planned outputs are described in Sections 2 and 5. Key learning outputs, which will be made available throughout the LEAN project, include:

- The creation of a Network Losses Reduction tool, which will allow DNOs to assess and select the most cost efficient blend of LEAN methods and options for their networks;
- Recommendation papers that may influence the future design of plant and network operation.
- Application studies demonstrating the impact of LEAN on losses, plant health and network operational costs to include a range of scenarios and a blend of LEAN options.
- Supporting materials to facilitate the widespread adoption of the LEAN method. This will potentially include new operational procedures, manuals and work instructions.

(ii) All DNOs need to focus on pro-active loss reduction from now on. Knowledge from the project will form the basis for implementation level confidence of LEAN amongst GB DNOs and the supply chain. As SEPD will demonstrate LEAN over a range of network scenarios and using different blends of LEAN options, learning is relevant to all GB DNOs.

Importantly, many of the projects delivered by DNOs require the increased use of electricity for transport and heating; this is to be expected and is necessary to prepare networks for a GB economy that becomes progressively more dependent on electricity. The rising use of electricity in the country's future economy means that the LEAN solution will be an especially useful complement to other LCNF projects.

(iii) A clearly defined knowledge dissemination programme is described in Section 5. The knowledge programme includes reports, workshops and seminars. However, SEPD proposes to introduce an innovative tool for knowledge dissemination. This is a Network Losses Reduction Tool, which will be available to DNOs to provide quick and easy cost-benefit analysis for losses management using LEAN techniques. In addition, the project website will feature innovative elements such as smart grid animations to help viewers understand the impact that current and future changes to the electricity networks will have on end customers. Details of these innovative learning tools are described in Section 5.

(iv) SEPD will use a standard framework to capture results from the project. Knowledge will be disseminated through various methods that are further detailed in Section 5. The project plan has included appropriate financial and work force resources for knowledge dissemination activities. Learning capture is defined throughout the project's SDRCs. Knowledge and learning content is peer reviewed and follow governance processes to ensure robustness before publication or presentation, as appropriate.

(v) It is SEPD's intention that the work undertaken using LCNF funding will adhere to the LCNF default IPR arrangements. However, this will be subject to confirmation depending upon the outcome of the commercial negotiations with equipment suppliers and SEPD's project partners. In all negotiations, SEPD will strive for maximum knowledge capture and sharing.

4.d Involvement of other partners and external funding

(i) SEPD engages with external collaborators when appropriate to do so and where this is cost-effective. LEAN is primarily a technical project and will largely require work to be carried out on SEPD's own network using its own staff. That said, several elements of LEAN may be delivered with the support of project collaborators. These include:

- Transformer specialists: this is for the purpose of asset selection and monitoring to ensure understanding of the effect the trials may have on asset health.
- An academic institution: this is to carry out data analysis and deliver knowledge dissemination. A private organisation may be contracted instead of an academic collaborator if this offers better value.
- The supply chain: this is to help ensure that the technical equipment required is available.

In order to ensure best value all of the above services will be sourced using SEPD's competitive and transparent procurement policy.

SEPD will also involve other DNOs, particularly in Phase 1, to seek input on the project. The project team has already met with ENW to discuss best working practice and collaboration between the LEAN project and ENW's Tier 1 Combined On-Line Monitoring project.

(ii) SEPD conducts a programme of stakeholder engagement, which includes ongoing communication with the supply chain and attendance at industry events. Regular engagement is undertaken through surveys, workshops and conferences, as well as one to one meetings. Throughout the year, SEPD's Future Networks team hold a series of internal workshops to identify, score and prioritise potential projects and check for best match against business as usual, Low Carbon Networks Fund and other funding streams.

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Evaluation Criteria continued

Figure 4.b SEPD's project selection parameters

The concept for the LEAN project arose as a result of internal stakeholder engagement aimed at seeking solutions to existing problem statements and discussions with the supply chain. In particular, the business sought ideas for solutions to address losses in a more pro-active way.

LEAN and all other potential project ideas are scored against alignment with the SEPD's business plan[5] and Innovation Strategy[7]. They are also reviewed for their potential for helping SEPD contribute to the Carbon Plan[3] and the European Commission's 2020 targets for the connection of renewables[2]. Once suitable projects are identified, their suitability for financial support through competitions such as Low Carbon Networks Fund is gauged.

The projects' level of readiness and scope for integration into business as usual processes is also considered. Research is undertaken to ensure there is no replication across the industry and to understand current learning on the key objectives the project looks to achieve. Initial approval to proceed with the project may then be sought by SSEPD senior management team.

The LCNF governance document references the ENA collaboration portal; this will be checked if funding is awarded, to investigate potential project suppliers and partners.

(iii) The LEAN project team will work with a group of project suppliers and collaborators that will be selected at the appropriate time, but these organisations are not required to seek other collaborators.

(iv) SEPD has engaged with internal stakeholders and with the supply chain to ensure in-house and procurement collaboration. Funding for the project is to come from LCN funding, should this be granted and SEPD's compulsory contribution.

4. e Relevance and timing

(i) The LEAN project is relevant to two recent initiatives:

There is a requirement for DNOs to procure lower-loss power transformers from 2015 with a further loss-reduction for procurement after 2021. The low annual replacement rate of long-lifetime assets means that it may take up to 60 years before all existing transformers are replaced with lower-loss units. The LEAN project will enable DNOs to optimise the losses of existing transformers not yet scheduled for replacement. It is estimated that the loss reduction achieved using the LEAN methods will save up to 90MWh per year, per substation, which is broadly similar to the loss saving achieved under the Ecodesign Directive per transformer.

In addition, the project's use of three different TASS options will enable the delivery of a report on the best method to be deployed for different levels of site demand compared with transformer ratings. Validation of Alternative Network Topology as a supplementary tool to complement TASS will also be reported. The outcomes may also enable DNOs to consider different procurement options in order to continue to achieve LEAN benefits after any site upgrade.

(ii) The LEAN project is relevant to DNOs' role in the move to a low carbon economy:

Ofgem advises that 1.5% of all carbon emissions in the UK currently arise from electrical losses. The full learning associated with the project can be implemented by DNOs to reduce losses and therefore reduce associated greenhouse gas emissions in time to help networks contribute toward the third Carbon Budget, which begins in 2018.

4. f Demonstration of a robust methodology and that the project is ready to implement.

(i) SEPD has created a robust plan for the project's delivery, with all responsibilities clearly detailed and interdependencies identified. The project plan can be viewed on Appendix 4.

(ii) The LEAN project is supported at all levels within SEPD, via its established Innovation Steering Board. Senior management are supportive and will be actively involved in the development and operation of the LEAN project. A dedicated project manager will be appointed to deliver the LEAN project, and the project budget has been checked to ensure that sufficient resource is allocated to the project's delivery.

(iii) The project will begin on 01 January 2015; the project plan evidences timescales and key delivery deadlines.

(iv) . Customer impact is discussed in Section 8. LEAN does not involve any interaction with customers, and includes mitigation against the risk of supply interruptions. The business case for LEAN, described in Section 3, states that the solution could provide more than £40 million in savings to customers. SEPD recognises that this figure is small when compared to the £1 billion in losses incurred each year. However, DNOs and Ofgem face several regulatory and policy drivers to address losses; LEAN represents a valuable method of achieving this aim.

(v) The costs estimated are based on a combination of SEPD's previous experience of implementing and delivering innovation projects, combined with information gathered during engagement with the supply chain. The budget is designed to be sustainable and accountable and all project budgets are peer reviewed before senior management may approve them. All of SEPD's project work is subject to regular review and internal audit and is maintained in a state of readiness for such activities.

(vi) There are no plans to request contingency funding, other than that indicated in Section 6.

(vii) If LEAN is proven through the project, the solution can be deployed on an individual basis using the decision tool that will be created as part of the project's knowledge dissemination programme.

(viii) The Successful Delivery Reward Criteria are detailed in Section 9. These have been reviewed by SEPD's Future Networks Management Team to ensure that they are of sufficient substance and quality.

(ix) SEPD's Regulation, Procurement and Legal teams have reviewed the project submission. Key data has been checked by S&C Electric Europe, the consultancy organisation appointed to support SEPD. The submission has been approved by the company's Innovation Steering Board and directors.

(x) All SEPD projects are subject to the company's governance and oversight processes. These include passing a series of 'gates' with specific, measurable targets for each gate. In addition, the project manager will have a project oversight manager to ensure compliance and as a point of escalation in the event of issues. Risk registers and mitigation measures are set in place to pro-actively manage the project and identify areas of concern. A copy of the LEAN project's risk register can be viewed on Appendix 6.

(xi) SEPD places significant focus on the careful and responsible management and expenditure of projects. Issues are flagged at and in-between project review 'gates' and a clearly defined escalation procedure is followed. In the event of any concern, e.g. the project is considered uneconomical or ineffective in terms of outcomes, including benefits to customers, it may be halted. The management team blocks the project's bank account in the event of halt, so that no further withdrawals can be made. In this instance, the appropriate SDRCs including a closedown report and all other governance concerning the project detailed in the Project Direction will still be required. Phase 1 of the project has a decision-making process incorporated at its conclusion; this is designed to ensure the project only proceeds if it is appropriate to do so. Full details of this are available in Appendix 12.

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Section 5: Knowledge dissemination

This section should be between 3 and 5 pages.

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5.1 Learning dissemination

Dissemination Strategy: The LEAN project's knowledge dissemination strategy consists of general learning dissemination and integration activities to support integration to GB DNO business as usual activity.

General dissemination targets a wide audience and aims to improve awareness of the ongoing project activity. It also places the project in the context of the GB systems and current and previous related research, and directs interested parties to the detailed and technical dissemination resources available.

The proposed tools for delivery of general dissemination include a dedicated website and representation at industry conferences. Integration activities are a key enabler for early integration of the project outputs into GB DNO business as usual (BAU). The project will develop DNO-relevant policy, standards and training to close the gap between the trial outputs and BAU. Training will be offered to stakeholders as outlined below.

Dissemination Target Audience: The LEAN project aims to engage with the following stakeholders:

- DNO operational staff and those who will be directly affected by internal change.
- DNO decision makers including asset managers, policy managers who are key to adoption of the LEAN philosophy.
- Those whose business models and operations may be impacted, including DNO's, generators and electricity suppliers.
- System providers and integrators, equipment manufacturers, academia and training providers who will deliver the services and resources for the future.
- Those who will need to consider the risk versus reward profile of the new approach (shareholders, policy makers, regulators, and transmission and distribution companies).

Dissemination Tools:

SEPD recognises that a diverse range of dissemination tools is key in sharing knowledge outputs arising from the LEAN project. Within each of the knowledge sharing elements, listed in Figure 5.a (left), the project team will produce a range of material that is informative and useful for its key stakeholders. These include SEPD and other DNO colleagues, industry peers and the supply chain in order to best integrate the LEAN solution into business as usual.

Figure 5.a LEAN knowledge media

Knowledge dissemination continued

Conferences

Display and presentation of the project at stakeholder and industry conferences is a useful tool to improve general awareness of the project in the early stages, and for sharing high-level outputs and detailed, printed matter in the later stages. The project will make use of QR codes at conference stalls to increase traffic to the project website, and encourage questions and feedback at events to improve clarity and accessibility of dissemination materials.

Early engagement with key stakeholders will improve buy-in, expand the project dissemination network, and give users an understanding of the project and its outcomes.

Project Website

SEPD will advertise the project website through QR codes on all dissemination material and via links on other relevant websites. The website will aim to be targeted to a mainly professional, industry audience and will feature:

- **Introductory video:** A high-level, accessible video will highlight the need for GB's low carbon future for environmental and sustainability and for future energy security. The footage will describe the role of loss reduction and the LEAN project in low-carbon Britain.
- **Target audience**: The website may require tailored navigation for different stakeholder types and viewers may be required to identify their interest at the outset of their visit. Certain aspects of the site would be publicly available but, as with most specialised networking sites, registration will be required to explore the more detailed and technical content.
- **Information capture**: Where appropriate, the website may provide an opportunity to gather feedback from stakeholders on the project and its objectives.

Dissemination Activities - Integration into Business as Usual

Field Visits and Practical Training

SEPD believes in the relevance and importance of practical training and creation of sturdy and safe operating procedures, and will work with project partners to develop these activities. Where feasible these activities will be supplemented by field visits to trial sites. This gives stakeholders an opportunity to understand the full range of practicalities involved in implementing the LEAN solution.

Feedback

SEPD is keen to appreciate the effect of knowledge sharing to its audience, and is interested to know of any actions and influences that may occur because of this. Seeking feedback on knowledge content and medium will help the company to implement ongoing improvements. An 'open book' approach with other DNOs is preferred so that learning is gives all parties the confidence necessary to deploy the LEAN solution on their own networks.

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Knowledge dissemination continued

Key Project Outputs and Tools

The LEAN project will demonstrate a cost-effective means to meet SEPD's licence obligation to 'ensure that losses are as low as reasonably practicable' whilst maintaining supply to customers and avoiding an adverse impact on asset health.

In addition, the project will report on the level of reduction in network losses achieved under a variety of network topologies, configurations and characteristics, customer loads and generation profiles. Lessons learnt from the project will identify the optimal configurations to enable wider LEAN deployment across the GB network.

Network Losses Reduction Tool:

A key output of the LEAN project is the development of an innovative Network Losses Reduction Tool. This will be launched following successful completion of the proposed trials and capture of corresponding lessons. The Network Losses Reduction Tool will enable DNOs to assess and select the most cost efficient methods and configurations applicable to their respective networks; this will drive reductions in network losses.

Training material

This project will produce draft amendments to existing SEPD planning and operational documents. In addition, the project will provide recommendations that may influence the future design of plant and network operation. Training materials will be available in a variety of formats to ensure the outputs are accessible to a wide range of stakeholders, but the main target audience will be the skilled industry personnel who will benefit from the outcomes of the project and may be involved in further LEAN deployment.

Use of Specialists and Academia in Supporting the LEAN Project:

LEAN requires the involvement of specialist, technical resources to implement the project successfully. SEPD recognises that universities have a key role to play in expanding the research base and knowledge dissemination from LCNF projects. Specific, measurable outputs for technical specialists and academic institutes will be identified during the early stages of the project. These will be used as the basis for an appropriate procurement exercise to select one or more providers.

Carefully consideration of the role of academia in the LEAN project has been undertaken as part of the project development stage; it is anticipated that any selected academic institution will take a key role in learning dissemination activities to include the development of training material, the Network Losses Reduction Tool and expansion of the research base.

Key Roles and responsibilities expected include:

- Identification of appropriate monitoring required for the selection of 'auto stop start' (and 'traditionally-operated') transformers during the project. Monitoring will be suitable to enable confirmation of changes to transformer health and associated operational treatment.

Knowledge dissemination continued

- Reviews of outputs from monitoring (installed by other organisations) to confirm existing and forecast future transformer conditions.
- Reports on all aspects of transformer condition arising from changing to Transformer Auto Stop Start operational arrangements.
- Support for knowledge dissemination of project findings throughout the industry.

Successful Dissemination

LEAN project outputs are applicable to all DNOs in across the UK. The development of a Network Losses Reduction Tool as part of the project will directly encourage DNOs to integrate the LEAN solution into their network BAU where appropriate to do so. The LEAN project team is confident that the outlined approach outlined represents the most effective methods for knowledge capture and dissemination and the successful integration of the LEAN solution across GB.

Successful delivery will be achieved by:

- Informing stakeholders of the reasons for change and scale of change.
- Sharing experiences to refine the learning of all parties and projects.
- Supporting stakeholders in the actions needed to change and promoting the solutions aimed at optimising network investment.
- Providing the ability to understand and influence stakeholders to educate their wider audiences.
- Providing documented learning outcomes to promote the wider adoption of innovative technical, commercial and social solutions.
- Providing a tangible focal point for engagement and dissemination.

5.2 IPR arrangements

It is our intention that the work undertaken using LCNF awards will adhere to the LCNF default IPR arrangements. However, this will be subject to confirmation depending upon the outcome of the commercial negotiations with equipment suppliers and SEPD's project partners. In all negotiations, SEPD will strive for maximum availability of the project work for dissemination and sharing purposes.

Project Code/Version No:
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Low Carbon Networks Fund
Full Submission Pro-forma
Section 6: Project Readiness

This section should be between 5 and 8 pages.

Requested level of protection require against cost over-runs (%):
0%

Requested level of protection against Direct Benefits that they wish to apply for (%):
Default - 50%

6.1 Readiness introduction

SEPD has completed a significant amount of research work over the past two years in relation to network losses. The IFI-funded '2013_04 Losses Reduction Study' (a review of which is contained in Appendix 2) completed a desk-based study into the theoretical benefits of a range of methods to reduce technical losses on the 33kV & 11kV networks. A number of techniques provided a positive business case at a high level and warranted additional investigation. It should be noted that the concepts being trialled are not in themselves technically challenging; in fact, transformers are switched on and off regularly. However, this project seeks to switch transformers with greater frequency to achieve loss reduction.

The intention is that this Tier 2 project is to further progress the initial results from the IFI study with additional detailed modelling planned and an assessment of the practicalities of implementing the methods identified in the earlier IFI project. The results of this analysis will help to identify the challenges associated with deploying these solutions in the field and will further define the potential benefits case.

The ultimate goal of the project is to deploy, demonstrate and analyse in detail the proposed methods in order to quantify the benefits in terms of losses and hence financial benefits to GB DNOs and their customers.

From the results of the practical trials, a Network Losses Reduction Tool will be created to allow DNOs to make strategic decisions in relation to network losses in a simple and timely manner, using currently recorded network parameters.

6.2 Project Start

The LEAN project is ready to commence; the project has already passed Gates 0 and 1 as defined in the company's governance procedures for projects, in early preparation for the delivery of the project. Key roles within the delivery team are filled and SEPD are prepared for the transition to full project delivery upon award of Tier 2 funding.

The LEAN project has been prepared with support received at all levels of SEPD management hierarchy (see Appendix 9). The project board (Innovation Steering Board) includes members of SEPD's senior management team including Mark Mathieson (Managing Director of Networks) and Stuart Hogarth (Director of Distribution), each of whom is actively committed to the successful delivery of the project.

The project team includes:

- Project Director: Stewart Reid (Future Networks Manager)
- Project Development Manager: Frank Clifton

- Project Manager: Alistair Steele
- Stakeholder Engagement: Avril Vera-Leon
- Engineering: Alan Broadbent (Head of Engineering)
- Protection and Control: Martin Lee
- Recruitment & Training Lead: Matthew Allan
- Learning & Dissemination Lead: Sorcha Schnittger
- Legal: Debbie Harding
- Regulation: Jenny Rogers
- Finance: Steve Kennedy and Davina Button
- Procurement & Commercial: Carl Lappin and Hamish Myles

The project team's availability to commence work in January 2015 has been agreed. Many of the team have been involved in the development of this Tier 2 submission. The core expertise within this team will continue into the LEAN project execution if funding is awarded, bringing continuity and focus on the objectives of the LEAN project. The work will start immediately upon project award with little need for an initial set-up period.

Following funding approval, further appointments will allow the team to move to delivery mode. An appropriate procurement exercise will take place to bring the necessary external resource (such as technical expertise) to aid with analysis work planned for Phase 1. The project will then proceed to delivery in line with the outline plan shown in Appendix 4.

The project team is primarily based in SEPD's Reading offices and supported by key staff in Perth. This existing structure ensures there are no barriers to the project starting on schedule.

6.3 Project partners are ready to be engaged

This project will bring together technologies and companies with relevant expertise to create a solution that is new to the GB network. SEPD has already engaged with a number of potential suppliers to ensure the project's objectives are met. This work will continue during the first phase of the project; firstly to deliver value for money to customers, and secondly, to ensure that there is a robust enough supply chain to support the widespread roll-out of the solution.

This first phase will also include engagement with a range of the historic manufacturers of SEPD's current portfolio of primary substation transformers. Initial discussions have been well received, with a positive response from a UK-based transformer manufacturer keen to be involved in the project. This will support the initial analysis work and inform the off-site testing to quantify the impact on transformer performance and asset life.

The final requirement is for support on the detailed analysis of the trial site performance and subsequent dissemination of this learning. This piece of work will be competitively procured to ensure appropriate expertise. Initial investigatory work suggests that there are a number of potential suppliers including specialist engineering consultants and academic institutions. In particular, there are universities that have comprehensive knowledge in the area of transformer condition monitoring. SEPD will engage with at least one of these academic institutions if they can meet the specific requirements.

SEPD will select project partners based on their national and international experience and knowledge in this field. Again, procurement will be fair and transparent; this may involve access to SEPD's existing framework agreement with external organisations. This will include the following roles:

- Project suppliers.
- Project management design and support.
- Technical specialist.
- Analysis support.
- Learning support.

Other roles may be identified as the project develops.

Throughout the project, but with considerable emphasis on Phase 1, other DNOs will be invited to contribute and offer insights. This is described in Appendix 12; SEPD is currently discussing collaborative working with ENW to optimise transformer-monitoring data sets using LEAN and their Combined On-Line Monitoring LCNF T1 project.

6.4 Project Costs and Benefits

Project Costs

The team has estimated LEAN project costs following the agreement of the project approach, the deliverables and the design of work packages. The project cost elements have been estimated based on discussions with manufacturers, suppliers and historic experience around similar research and development projects. Where available, reference has been made to publicly available source information, international comparisons, and academic input to ensure these are as robust as possible at this stage.

The key cost elements are identified below:

Work Package	Description	Cost
WP1	Pre trial analysis and testing	[redacted]
WP2	Detailed site selection and functional specifications	[redacted]
WP3	Development of trials	[redacted]
WP4	Monitoring and analysis of trial sites	[redacted]
WP5	Knowledge and dissemination	[redacted]

Figure 6.1 LEAN project key element costs

The LEAN project's total cost is £3.07m. Further details are included in Appendix 1, which contains the Full Submission Spreadsheet (Appendix 1).

6.5 Cost Estimates and Work Breakdown Structure

The costs for each work package are described in each of the sections below. Costs have been allocated by estimating labour costs for SEPD and the project partners, and materials, travel and accommodation, in addition to TASS and ANT deployment costs. All costs are correct at the time of the bid submission; however, these will be refined as the project develops. The Full Submission Spreadsheet (Appendix 1) contains details of all costs for the project. Costs include staffing resources for the project team, including a full-time Project Manager and Project Engineer, and additional support from SEPD's Project Delivery Manager when required. The labour rate associated with these tasks is an SEPD standard labour rate [redacted] per day. Project Management costs have been integrated into each work package to facilitate transparency within the project's spend profile.

WP1 Pre-Trial Analysis & Testing: This section of work covers a number of areas. Firstly, an understanding of actual losses in real terms will be measured at a range of sites to inform and validate the detailed modelling work. Costs will cover site works, installation of monitoring equipment and analysis. This will include work with a transformer specialist to develop trial details, risk mitigation and advice on long-term asset health. SEPD will also engage with the manufacturers of SEPD-owned transformers to gauge their input to the project.

Prior to deployment, SEPD plan to undertake an 'off-grid' trial on a transformer to assess the impact of repeated switching operations on a transformer asset health. The results from this test will be crucial to inform the further deployment of the LEAN solution. This will also allow the project to establish effective and relevant data points. Outputs from WP1 will result in a detailed requirements specification that can be used to undertake a 'market test' for potential equipment suppliers.

The second part of this package covers the detailed modelling and analysis to quantify the benefits case. This work will validate the high-level studies completed under earlier IFI-funded projects.

WP2 Detailed Site Selection & Functional Specifications: Site selection will be completed by the LEAN project team in conjunction with SEPD colleagues. In parallel with the site selection process, the equipment requirements specification will be developed with the project team, SEPD's procurement department and through engagement with suppliers.

At the end of this work package, thorough investigation of all of the major assumptions and risks identified during the development of the bid will be complete. This will allow validation of the business case and give SEPD sufficient confidence to move forward to deployment.

WP3 Deployment of Trials: The costs associated with deployment are split into three categories, based on the TASS option selected. This will be informed by the results and learning gained from WP1 and WP2. These costs relate to installation of necessary electrical equipment at substations, and IT and communications infrastructure at strategic points on the network.

WP4 Monitoring & Analysis of Trial Sites: To ensure that benefits in relation to losses are captured accurately, monitoring equipment will be installed at the trial sites. This

Project Readiness continued

monitoring will also evaluate the impact of the LEAN solution on the assets and will ascertain that there are no adverse impacts on the quality of supply. The second part of this package relates to data analysis; part of this will be completed by SEPD and the remainder allocated to a specialist.

WP5 Knowledge and Dissemination: Knowledge dissemination is phased over the duration of the project to share learning on an incremental basis, and to help integrate LEAN into DNO business as usual practices quickly and confidently. As with WP4, the scale of the work will be informed through the number of trial sites implemented.

6.6 Measures to Reduce Cost Over-Runs

The LEAN project will be managed in accordance with SEPD's Future Networks and Policy established Programme Management Procedure. This is a whole-lifecycle tool, designed to ensure projects are governed, developed, approved and executed in a consistent and effective manner, with consideration of best practice in project delivery. As this project uses this framework as a basis, sufficient rigour is employed to confirm the project is well controlled and managed, and will lead to a successful conclusion. Additionally, the same successful management formulae used for previous LCNF T2 projects (New Thames Valley Vision and Solent Achieving Value through Efficiency) will be extended to this project.

The governance framework is phased with three gates at appropriate decision points, with clear, consistent deliverables for each gate. Project governance rules are established and defined for each phase, with standard project organisational structures and key roles.

As the LEAN project develops through the inception and opportunity assessment, it is subject to stage gate reviews. The initial reviews consider project readiness and the underlying needs case in order to allow the project to proceed, or ascertain whether further re-working is required. Similarly, as the project enters key stages, it will be reviewed to assess the cost and completion of deliverables.

Each of the detailed work packages has identified associated risks and developed mitigating actions to form the basis of the contingency plans. Risk management will be conducted under the auspices of the SSEPD FNPMP 'Project Risk Management Plan'.

The LEAN project has been constructed as an integrated whole, and any scope changes (if required) by Ofgem prior to project award will require a period of re-planning and possible re-negotiation with collaborators and suppliers. This type of requirements may delay commencement and completion.

6.7 Benefits Estimates

The following process has been adopted to estimate the benefits of the project:

§ Initial benefits were identified by the LEAN project team based on the high-level work completed under IFI.
§ These initial benefits were peer reviewed by S&C Electric Ltd (consultant for the LEAN

project) to produce a revised, independent view of the potential benefits.

- Given that the benefits are comprised of both direct and indirect benefits, they are considered accurate to within +/-25%.

In general, a very cautious view has been taken in estimating the potential benefits that LEAN will enable. However, even in the worst-case scenario of maximum cost and minimum benefits, the project still has a robust business case.

The benefits case is based on current, typical load duration curves. Evidence strongly suggests that these curves will change due to the continued adoption of low carbon technology by customers (such as solar panels) and its impact on the grid. This may lead to reduced utilisation of primary substations, which should provide more opportunities to deploy the LEAN solution.

6.8 Minimising Shortfalls in Direct Benefits

The LEAN project does not involve the use of any direct benefits.

6. 9 Quality Plan

All information contained in this proposal (including the appendices) has been subject to a rigorous peer, external expert and SEPD management review process to assure validity and accuracy.

A review meeting is held to examine the status of a project prior to any significant cost commitment such as equipment procurement. Concerns must be satisfied before a project team may make a large purchase; any concerns that cannot be satisfied follow a strict escalation procedure, with Ofgem informed if this is the next appropriate action.

6.10 Process for Suspending the Project

The project is subject to the company's gated project management process, and at each gate, the project's feasibility and risks will be reviewed before a project may proceed to the subsequent gate.

The first phase of the project has been specifically designed to allow further detailed work on the rationale and assumptions that underpin the LEAN project. This will be used to verify that the business case detailed in the original submission is still realistic. Furthermore, regular risk review workshops exist to escalate a significant risk or issue that requires a decision on the feasibility of the project. Any resulting proposed change to the project or request to suspend the project would then be submitted to Ofgem for approval.

6.11 Project Programme

The outline project programme is included in Appendix 4.

6.12 Risk Management and Contingency Planning

The project incorporates a number of innovative elements ranging from technology to operational practises and procedures. Consequently, a degree of risk and uncertainty needs to be managed. The work breakdown structure and the utilisation of SEPD's established Governance Framework will ensure that any risks are identified and monitored with appropriate mitigations in place.

The full project Risk Register is included in Appendix 6 and the Contingency Plan in Appendix 10. This sets out the primary risks for the project and the mitigations and contingencies that will be put in place to manage these risks.

6.13 Successful Delivery Reward Criteria:

The Successful Delivery Award Criteria have been developed in conjunction with SEPD's project plan to ensure the criteria align with the core project objectives and milestones (see Section 9 for more details).

6.14 Delivery of Learning

The focus of the LEAN project is to compare the theoretical modelled results with actual results from the implementation of trials across an arrangement of network equipment in diverse locations. Results from the trials will validate the outputs of the initial Network Losses Reduction Tool. This tool will be able to be utilised by GB DNOs to make informed decisions on aspects of the networks that would benefit from TASS implementation.

6.14 Uptake of Low Carbon Technologies

The LEAN project does not rely on the uptake of low carbon technologies or renewable generation in the trial areas. The LEAN solution will still deliver benefits when implemented on the existing network. The uptake of low carbon technologies and the installation of renewable generation will only serve to improve the LEAN business case.

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Section 7: Regulatory issues

This section should be between 1 and 3 pages.

☐ Please cross the box if the Project may require any derogations, consents or changes to the regulatory arrangements.

7.0 Derogations and requests to change regulatory arrangements

The LEAN project is within the scope of the regulations and no derogations, licence consents or changes to regulatory changes are anticipated.

While the project intends to make significant changes to the operation of SEPD's 11kV and 33kV network, this will be achieved whilst avoiding any transgressions from existing network planning and operating standards. In consequence, it is not envisaged that the project will require any derogations or exemptions. Future changes to the regulatory arrangements where these would further assist DNOs in loss optimisation, may be highlighted through the project findings.

The project team will pay particular attention to the Energy Networks Association's Engineering Recommendation P2/6 'Security of Supply' (2006)[8] and any impact of the proposed methods to operate HV networks in novel configurations.

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Section 8: Customer impacts

This section should be between 2 and 4 pages.

8.1 Interaction and engagement with customers

Electricity losses for all elements of the electricity network; distribution, generation and transmission, account for around 7% of an average domestic customer's bill. Therefore, any initiatives that reduce losses will have a positive effect on these bills. LEAN seeks to develop methods that will reduce losses and therefore, benefit customers.

The project is completely technical in scope; the two LEAN methods (Transformer Auto Stop Start and Alternative Network Topology) are designed to reduce losses through switching and reconfiguration of selected 33kV/11kV transformers and the 11kV circuits respectively.

No aspect of the trials is expected to require direct interaction or engagement with customers as part of its scope.

8.2 Planned and unplanned interruptions

The implementation of the LEAN project does not require any planned interruptions to customers' supplies and there is no request for protection from incentive payments. Security of supply is of critical importance to SEPD; trials may only proceed when any risk are reduced to an acceptable level. Site selection will be carried out carefully, taking into account load types such as sensitive loads. Mitigation against flicker in supply quality and harmonics has been included and contingency has been added. The implementation of ANT will also serve to prevent detriment to supply quality. The first phase of the project is vital in establishing the risks and provision of contingency – this is described in Appendix 12. Monitoring will continue throughout the operational phase of the project.

The LEAN project involves planned work on 33/11kV transformers at primary substations where there is already sufficient flexibility to enable this work to proceed without interrupting customer supplies. In designing the project, SEPD's project team has taken great care to establish outputs and methods in such a way as to protect customers from any unplanned interruptions.

Section 2 of this document contains a description of the project, which includes:

- **Desktop modelling and site selection**: the initial modelling and analysis work will identify a number of potential sites that may benefit from LEAN. The site selection process will include detailed consideration of network connectivity; customer numbers; number of PSR customers; customer types; and sensitive loads to ensure that the site is appropriate for the trial.
- **Input from a transformer specialist to assist in the design of the trials**: this specialist will provide advice and support to avoid any adverse impacts on either asset health or network integrity.
- **Validation with supply chain**: the project team will seek further input from the original equipment manufacturers of the transformers that may be involved in any trial. Knowledge capture will inform the project team of any issues associated with switching so that preventative action can be taken against adverse impact on the plant.

Customer impacts continued

- **Off-network trials**: this activity will allow the project team to implement testing in a controlled environment where supply integrity is not affected.
- **Functional specification**: the outputs from the activities listed above will inform a detailed performance specification for equipment which will be implemented for the LEAN solution.
- **The de-energisation of one of a pair of transformers:** this part of the trials, whilst significantly reducing losses, will have an impact on the level of redundancy within the network. This impact will be mitigated by deploying the second method, of Alternative Network Topology (ANT) ANT involves additional automation and remote control of the 11kV network to maintain supplies. These measures will be augmented with robust contingency plans to avoid any unplanned interruptions to customers' supplies. For example, upon receipt of adverse weather warnings, which may include the potential for disruption on the network, the project team will invoke a disablement to the TASS solution to preserve network resilience. It is important to note that single-transformer operation is scheduled to occur during periods of low demand only.

The project proposes additional transformer monitoring that includes both the selected (de-energised) transformer and the remaining (energised) transformer. The project will incorporate detailed baseline inspections to ensure that equipment included in the initial trials is fully functional. The project team will deploy additional monitoring and inspection during the operational phase of the LEAN project. These mitigation steps will provide early indication of potential failure modes so that SEPD can take appropriate preventative action.

Frequent switching activity may carry a risk affecting power quality i.e. flicker in supply and harmonics, therefore SEPD will factor mitigation against this into the project's risk and contingency planning. Appropriate measurements will be carried out at the trial locations in advance to measure background power quality; this will continue to be monitored during the operational phase of the trial. During the operational phase of the project, the local operational staff , emergency service centre and network management centre will all be briefed with suitable contingency plans in place to respond to any reports which suggest that the project is having a detrimental impact on quality of supply. If there are any indications that power quality has been impacted, work will halt until a suitable resolution can be identified. Security of supply is of critical importance to SEPD and the trials will only go ahead when risks are reduced to an acceptable level.

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Section 9: Successful Delivery Reward Criteria

This section should be between 2 and 5 pages.

9.0 The following section describes the Successful Delivery Reward Criteria for the project, the completion of which are key milestones and indicators of the overall success of the LEAN project. Progress against these criteria will be monitored and reported on during project delivery.

Criterion 9.1 Project setup and review of related projects:

- Finalise work breakdown structure.
- Review and complete project programme.
- Produce report on GB and international projects related to reduction of losses in distribution networks including recommendations and key suggestions to improve the project design and implementation.

Evidence: The final WBS and programme submitted to Ofgem and a report detailing the project recommendations will be delivered by 31 July 2015.

Criterion 9.2 Business case validation:

- Completion of transformer losses testing within relevant environment, to facilitate an in-depth review of the business case for Transformer Auto Stop Start (TASS) using measured transformer losses figures and specific SEPD network data.
- Confirm or reject the technical validity of each switching method.
- Present results of phase 1 work packages to complete business case for rollout of each TASS option with ANT if applicable

Evidence: A report detailing the work completed to date and an interim version of the losses evaluation tool by 31 March 2016 which considers in detail the predicted costs for each option against the lifetime benefits.

Criterion 9.3 Phase 2 decision point:

- Internal presentation of results to business representatives.
- External presentation of results with considered stakeholders including GB DNOs.

Evidence: Written confirmation from external stakeholders that the solution proposed in conjunction with the projected benefits is applicable for GB wide rollout. In order to move into Phase 2 of the project, the modelling work must show a positive return on investment and acceptably mitigate the risk to network security and asset health.

Criterion 9.4 Initial learning from trial installation and integration:

- Installation of appropriate equipment at multiple sites.
- Appropriate learning captured from the installation and commissioning of equipment on site.
- Details of the system communications and control functionality.
- Initial results of the site performance.

Evidence: A report including lessons learnt on all aspects of the integration and subsequent challenges to Ofgem by November 2017.

Criterion 9.5 Monitoring & analysis:

- In depth review of the techniques used to monitor transformer health
- Interim feedback on the performance of the implemented sites.
- Initial assessment of asset health before and after TASS operation.
- Data to quantify the electrical impact on the network in terms of power quality.

Evidence: An interim report will be provided to Ofgem by 31 March 2018 in conjunction with appropriate evaluation of the various transformer health monitoring techniques employed.

Criterion 9.6 Site performance to date:

- Full scale review of the site performance in relation to losses.
- Losses compared with asset health to quantify the actual benefits.
- Benefits used to quantify the cost of sites operation and hence prove or disprove the business case.

Evidence: A report detailing the operational benefits / challenges of the system to date. In addition site visits will be offered to Ofgem and appropriate stakeholders, internal and external.

Criterion 9.7 Network losses evaluation tool:

- Completion of a Network Losses Reduction Tool so that DNOs can clearly assess cost benefits analysis of LEAN deployment on specific sites within their networks.
- Internal SEPD training for network planning engineers and plan for potential integration into 'Business as Usual' practices.

Evidence: The tool will be presented to Ofgem in final format. A standardised SEPD work instruction / technical guide will be published. Both of these outputs will be delivered by December 2018.

Criterion 9.8 Knowledge & dissemination:

- Project closedown report including 'Network Losses Reduction Tool' analysis.
- External workshop to present tool and project outcomes.
- Plan produced to integrate the loss saving techniques into the business for a large scale rollout if applicable.

Evidence: Produce final report and present to Ofgem by 31 March 2019.

Low Carbon Networks Fund
Full Submission Pro-forma
Section 10: List of Appendices

Appendix	Title
1	Full Submission Spreadsheet (not included in Public Version)
2	Key Learning from T1 and IFI projects
3	Network Maps and Diagrams
4	Project Programme
5	Supporting Information for Business Case (& Benefits Table)
6	Risk Register
7	Technology Review
8	Technical Background
9	Organogram
10	Contingency Plan
11	Reference Notes
12	LEAN Phase 1

SSET207 – LEAN – Appendices

Appendix	Title
1	Full Submission Spreadsheet
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3	Network Maps and Diagrams
4	Project Programme
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6	Risk Register
7	Technology Review
8	Technical Background
9	Organogram
10	Contingency Plan
11	Reference Notes
12	LEAN Phase 1

SSET207 – LEAN APPENDIX 1 – Full Submission Spreadsheet

The complete Full Submission Spreadsheet was submitted separately via the FTP site. The table below summarises the Outstanding Funding request;

Outstanding Funding required (£k)							
	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	**Total**
Labour	48.60	290.70	282.60	259.20	196.20	-	**1,077.30**
Equipment	-	40.50	193.50	255.60	-	-	**489.60**
Contractors	18.00	202.50	207.00	134.10	88.20	-	**649.80**
IT	-	4.50	28.80	-	-	-	**33.30**
IPR Costs	-	-	-	-	-	-	**-**
Travel & Expenses	-	49.50	106.20	72.00	27.00	-	**254.70**
Payments to users & Contingency	-	-	-	-	-	-	**-**
Decommissioning	-	-	-	-	49.50	-	**49.50**
Other	-	27.00	180.00	-	-	-	**207.00**
Total	**66.60**	**614.70**	**998.10**	**720.90**	**360.90**	**-**	**2,761.20**

SECOND TIER FUNDING REQUEST £	**2,669.96**

SSET207 – LEAN APPENDIX 2: Key Learning from Tier 1 and IFI Projects

IFI Advanced Radio Control (2011-2016)

SEPD selected the Isle of Wight to demonstrate the performance of an automated feeder self-healing solution featuring distributed intelligence. The Isle of Wight was chosen for the pilot project because its network layout is representative of typical SEPD network layouts. In addition, the area is subject to severe weather conditions that would rigorously test the performance of the self-healing solution.

The eleven 11 kV feeders, shown in Figure 1 (single-line diagram showing feeder breakers, feeder segmentation using S&C Electric Company's IntelliRupter PulseClosers, and normally open feeder inter-ties), include a mix of underground and overhead feeders. The switching device locations selected for automation were chosen based on cost justified reliability improvement calculations. These calculations considered the impact on Customer Minutes Lost (CML), total load lost, and customer interruptions, and took into account the following factors:

- Fault rate;
- Average time to switch;
- Average time to complete a repair; and
- Underground/overhead splits.

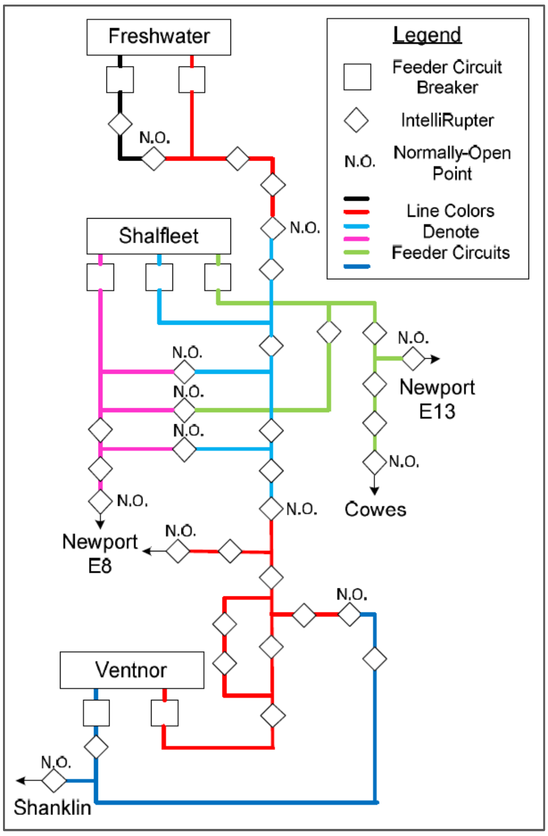


Figure 1 Isle of Wight Automated Feeder Self-healing Solution

SEPD began installation of the S&C IntelliTeam II® Automatic Restoration System on the Isle of Wight in 2008. The project included 32 new S&C's IntelliRupter® PulseClosers, installed at interim-feeder locations among the 11 kV interconnected circuits. Additionally, S&C's Universal Interface Modules (now termed IntelliNode™ Interface Modules) were installed in three primary substations associated with the eleven feeders to enable inclusion of the seven feeder breakers as IntelliTeam II® sources.

Principle lessons learnt from this ongoing project include the following:

- At the conclusion of the pilot project, the technological benefits of PulseClosing Technology™ and economic benefits of reducing CML were repeatedly demonstrated.
- Much was learned about eliminating the load-restoration responsibilities of SCADA operators, thus freeing them to focus upon wide-area system events, and post-restoration results.
    - o A wide range of device and automation system status parameters are available for SCADA information or action. But the large number of alarms initially mapped to SCADA resulted in data overload, and operators eventually began ignoring some important alarms. Consequently, SEPD learned that it was better to parse some indications to engineering personnel for their review and action, and minimize the number of alarms sent to SCADA.

- SCADA operators should be trained in instalments during the project, with the initial training focused on the operating differences between IntelliRupter and conventional re-closers.
- SEPD should plan for incremental commissioning for large systems, and recognize that SCADA operators will need help in understanding which portions of the system are now automated.
- The importance of parsing automation system and component alarms to appropriate departments was eventually recognized.

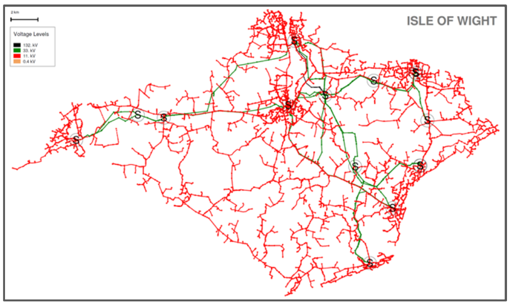
- Increased feeder segmentation can be achieved with IntelliRupters if alternate coordination strategies and practices are embraced.
- It was also seen that communication reliability is heavily dependent upon following the specifics of site surveys, and that strategically locating communication-based equipment can vastly improve the access for all system devices.
    - Wifi access to all 32 IntelliRupters, for configuring and testing the devices during start-up, would have been greatly simplified had a few IntelliRupters been located closer to public roads.

2 IFI Isle of Wight Network Losses Reduction Study (2013-2014)

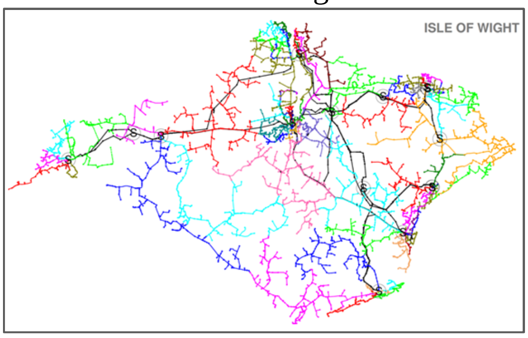
SEPD commissioned S&C Electric Europe Ltd., in partnership with LIG Consultancy Services LLP and The University of Bath, to undertake a desktop based detailed technical feasibility and cost benefit analysis of potential network interventions to reduce the Isle of Wight's 11kV distribution network electrical losses. A comprehensive set of network interventions were considered as listed below and were investigated in detail; network loss reduction performance for each intervention and associated cost-benefits were benchmarked against the existing business as usual network..

- Network automatic reconfiguration;
- Meshed network operation;
- Transformer automatic switching;
- Incorporating energy storage;
- Conservation voltage reduction; and
- Network voltage upgrade.

A detailed model (as shown in Figure 2) of the island's 11kV network from 33/11kV primary transformers down to 11 kV/LV secondary transformers and a high level model of its 33kV and 132kV networks maintain system fault levels was developed in DIgSILENT PowerFactory based on detailed SEPD data. Annual half-hourly 11kV feeder data for the year 2012, extracted from SEPD's PI data historian system, was modelled and distributed in the network using the feeder scaling tool. To reduce computational burden, the study selected 8 representative days (weekday and weekend for each of four seasons) using relevant meteorological degree-day data to group data into seasons. Study results were then extrapolated to represent the annual demand over 2012.



a. Network Voltage Levels



b. Network Feeders

Figure 2 Isle of Wight Geographic Distribution Network Model

In assessing the technical performance of the considered cases, detailed time dependent simulations were undertaken in DIgSILENT PowerFactory software to establish the Isle of

Wight 11 kV network electrical losses, voltage profile, equipment thermal loading, and short-circuit levels. A high-level expert opinion based assessment was also undertaken for each case to qualitatively establish the networks voltage step-change, reliability and protection performance and identify potential related operational risks and constraints. The cost-benefit analysis for each considered intervention was undertaken using OFGEM's ROI methodology, capturing the following cost-benefit metrics: capital investment, avoidable DNO costs, non-DNO benefits, societal benefits, and net (and cumulative) benefits.

Principle lessons learnt from this study include the following:

Study technical findings:

- Network interventions with significant electrical loss and carbon savings from the business as usual network and those indicating a positive Return on Investment were identified as following: transformer Auto Stop Start with Alternative Network Topology, transformer Auto Stop Start acting alone, and conservative voltage reduction (assuming a unity voltage load dependency).
- The greatest electrical losses reduction was found to be achieved when the 11 kV network is upgraded to 22 kV, but the overall cost would likely prohibit this approach. It may be appropriate, however, to consider a rural voltage upgrade, so as to avoid majority of costs due to underground cable replacement required as part of this intervention. It may also be appropriate to consider if rural 11 kV overhead feeders may be cost effectively upgraded to 33 kV, especially where reinforcement is necessary for embedded generation connections.
- Addition of embedded generation connecting at Isle of Wight 11 kV network had the following impact:
  - Embedded generation may increase total 11 kV network electrical losses; however, system wide electrical losses (400 kV to LV) may reduce.
  - The transformer Auto Stop-Start with Alternative Network Topology intervention remained as the most cost-effective solution, with similar payback periods.

Cost-benefit assessment findings:

- Several interventions that indicate a positive Return on Investment over reasonable timescales were identified. In addition to their suitability for practical demonstrations as network loss reduction innovations, no significant barriers to their deployment were identified.
- Alternative Network Topology was found to give the quickest return on investment, although the expected return on investment and sensitivity to higher network losses growth rates is low. However, in comparison the Auto Stop-Start with Alternative Network Topology intervention is expected to give a greater return on investment and improved sensitivity to higher network losses growth rates.

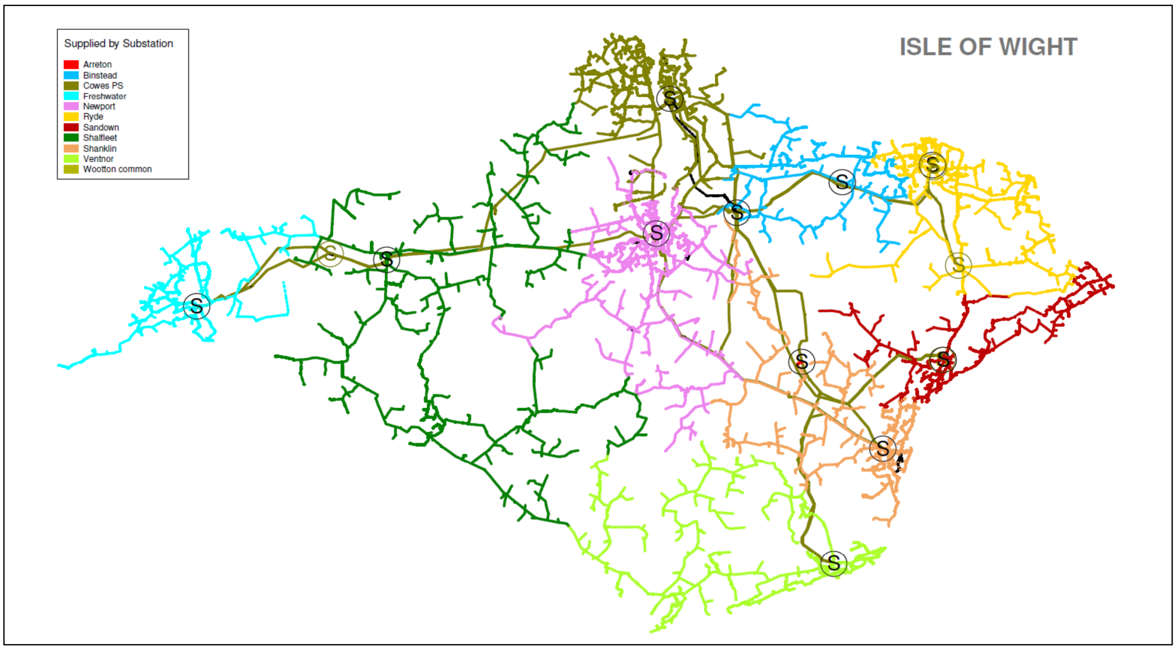
Among the considered interventions, the transformer Auto Stop Start acting alone, or its combination with Alternative Network Topology, is found to be the optimal intervention solution (accounting for both network technical and cost-benefit metrics offered by these interventions) in reducing Isle of Wight's network losses.

SSET207 – LEAN Appendix 3 – Maps & Diagrams

The images included illustrate a specific section of the 33kV and 11kV networks on the Isle of Wight. This is fairly representative of networks across GB with dual transformers at each primary substation and a reasonable level of interconnection on the 11kV network.

- Figure 1 - illustrates the number of primary substations located on the Isle of Wight and the 11kV network associated with each primary. These have been colour coded to ease understanding.
- Figure 2 – illustrates the 33kV schematic for the island. This illustrates that the majority of primary substations have two transformers.
- Figure 3 - provides a detailed view to illustrate the network between Sandown and Ventnor substations and clearly identifies that the TASS solution could be implemented between two interconnected substations fed by four transformers.
- Figure 4 - The final image is a simplified view of the equipment required to be installed at a site in order to implement TASS.

Figure 1 - Geographical view of the Isle of Wight 11kV network



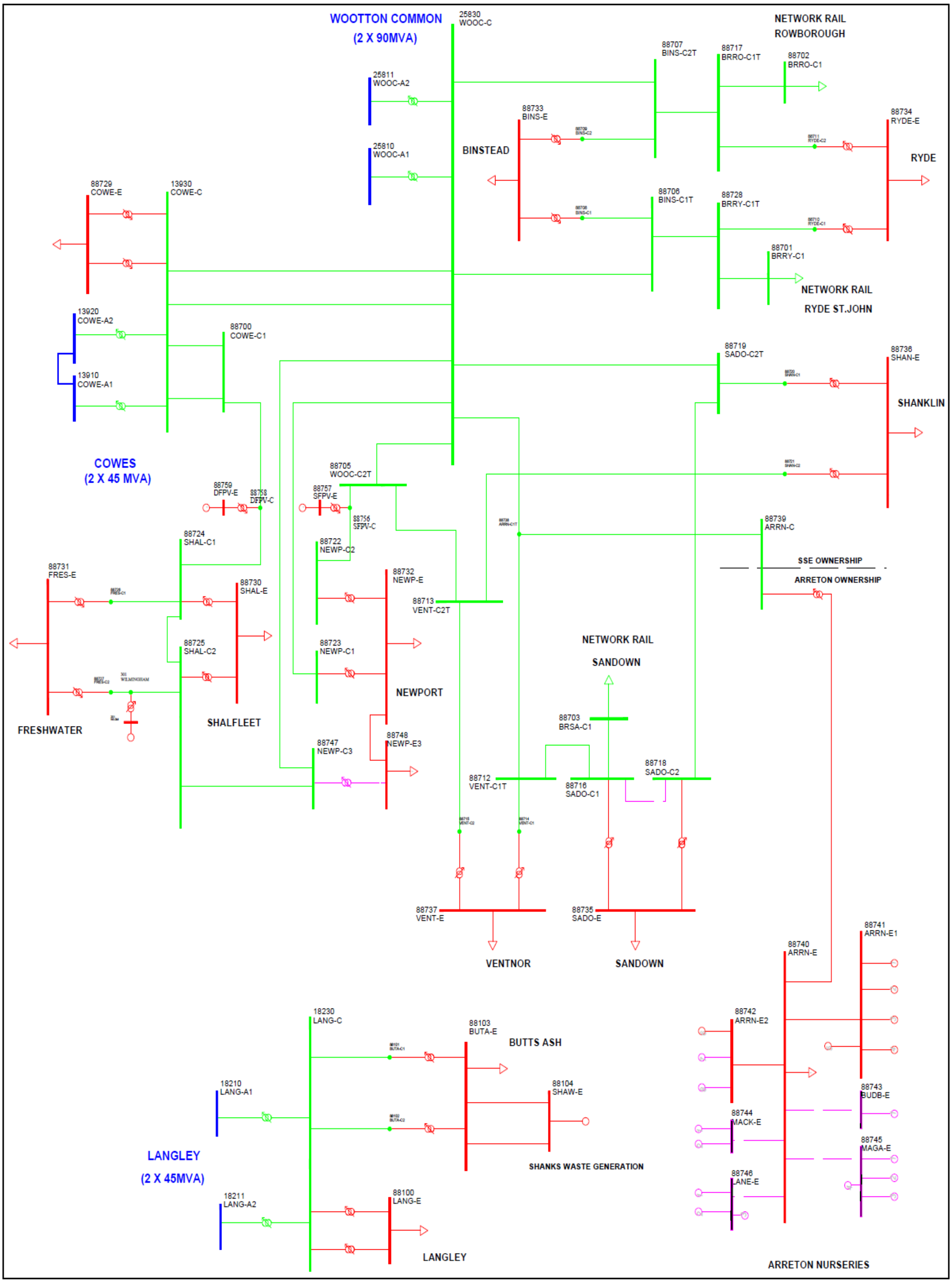


Figure 2 - Electrical view of the Isle of Wight 33kV network

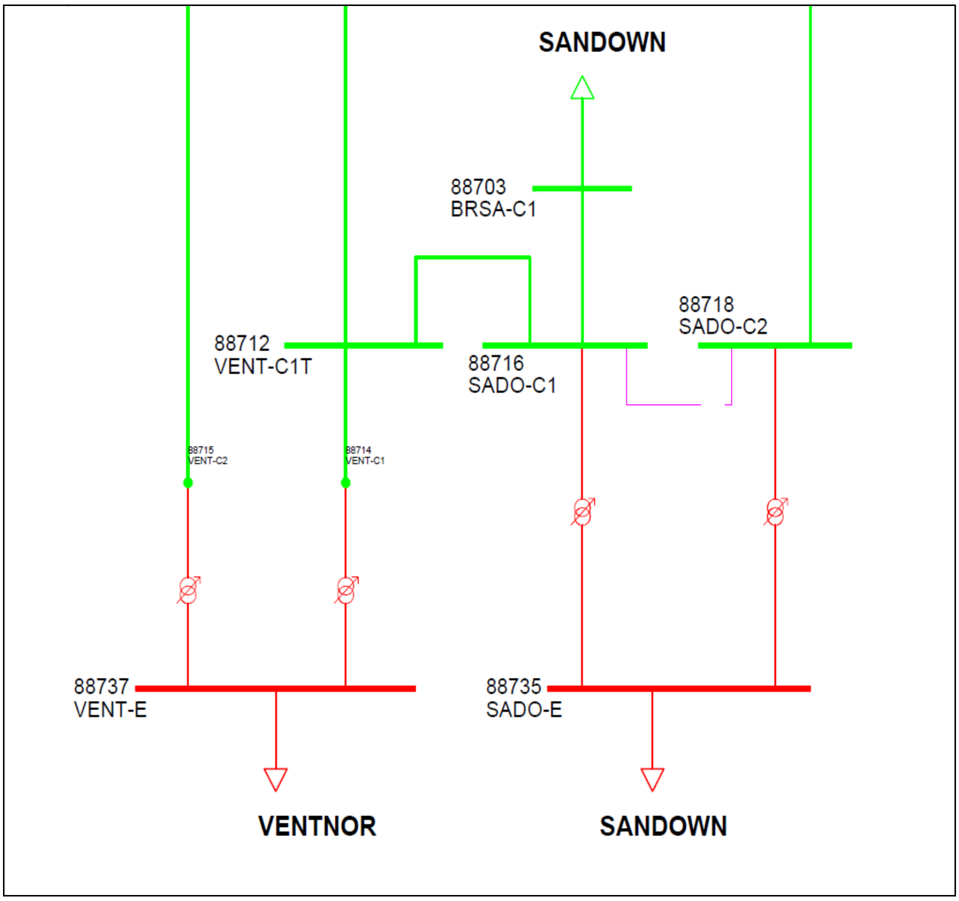


Figure 3 – Detailed schematic illustrating two interconnected substations

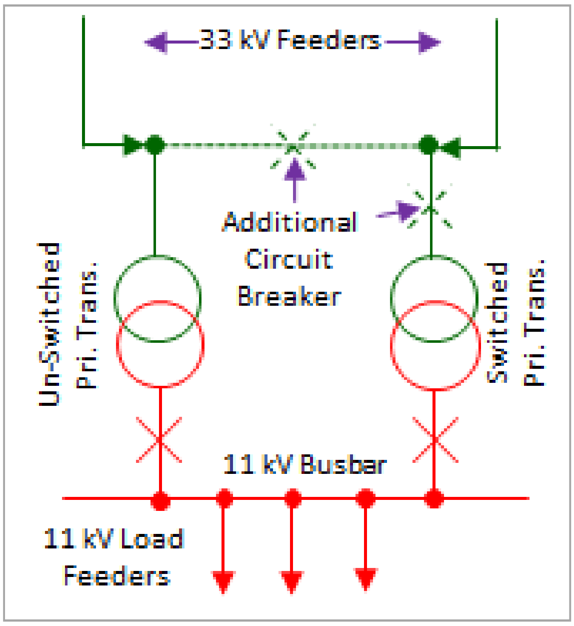


Figure 4 - Simple diagram of Alternative Network Topology

SSET207 - LEAN Appendix 4 – Detailed Project Plan

ID	Indicators	Task Name	Start	Finish	Predecessors
1		**Phase 1: Task 1 - Detailed desktop analysis, extension of the business case**	**Thu 01/01/15**	**Thu 31/12/15**	
2		**Detailed desktop analysis, extension of the business case**	**Thu 01/01/15**	**Wed 01/07/15**	
3		Validation of pre-bid studies and business case	Thu 01/01/15	Fri 27/02/15	
4		Investigation into previous loss reduction projects / techniques on distribution networks	Mon 02/03/15	Tue 28/04/15	3
5		Technical and commercial modelling and studies	Wed 29/04/15	Tue 30/06/15	4
6		SDRC 9.1 - Project setup and review of related projects	Wed 01/07/15	Wed 01/07/15	
7		**Detailed investigation of transformer impacts**	**Thu 01/01/15**	**Thu 31/12/15**	
8		Identification of transformer specialist(s)	Thu 01/01/15	Fri 27/02/15	
9		Validation of assumptions; identification of risks / mitigations	Mon 02/03/15	Mon 29/06/15	8
10		Input into measurement & monitoring equipment/methods	Mon 02/03/15	Tue 28/07/15	
11		**Supply-chain engagement with transformer OEM**	**Thu 01/01/15**	**Fri 25/09/15**	
12		Validation of assumptions; identification of risks / mitigations	Wed 01/04/15	Fri 25/09/15	
13		Input into measurement & monitoring equipment / methods	Thu 01/01/15	Mon 29/06/15	
14		Input into off-site network testing / trials	Mon 02/02/15	Mon 01/06/15	
15		**Off-Site trials**	**Mon 02/03/15**	**Fri 30/10/15**	
16		Identification of site / transformer for off-network testing	Mon 02/03/15	Fri 29/05/15	
17		Development of testing procedures	Mon 01/06/15	Fri 31/07/15	
18		Input into test equipment specification preparation	Mon 01/06/15	Mon 31/08/15	
19		Testing, analysis, and reporting of results	Tue 01/09/15	Fri 30/10/15	18,17,16
20		**Documentation & validated business case**	**Mon 02/11/15**	**Thu 31/12/15**	
21		Findings from International literature review	Mon 02/11/15	Wed 02/12/15	
22		Updated business case	Thu 03/12/15	Thu 31/12/15	21
23					
24		**Phase 1: Task 2 : Detailed Site Selection & Functional Specifications**	**Mon 01/06/15**	**Mon 04/07/16**	
25		**Prepare network matrix (decision tool)**	**Mon 01/06/15**	**Thu 01/10/15**	
26		Tool requirements defined and documented	Mon 01/06/15	Fri 31/07/15	
27		Tool developed and tested	Wed 01/07/15	Tue 01/09/15	
28		Tool finalised and guidance notes written	Wed 02/09/15	Thu 01/10/15	27
29		**Input data to decision tool and carry out review of network**	**Wed 01/07/15**	**Tue 01/12/15**	
30		Detailed investigation of load profiles across SEPD network	Wed 01/07/15	Mon 31/08/15	
31		Technical data obtained and verified for SEPD network	Tue 01/09/15	Fri 30/10/15	
32		Initial selection of sites for LEAN deployment	Thu 01/10/15	Tue 01/12/15	
33		**Review and select substations for trials, incl. site visits**	**Wed 01/07/15**	**Wed 02/12/15**	
34		Initial selection of sites for LEAN deployment	Wed 01/07/15	Mon 31/08/15	

ID	Indicators	Task Name	Start	Finish	Predecessors
35		Internal review of proposed sites incl site visits	Tue 01/09/15	Fri 30/10/15	34
36		Final selection of sites for LEAN deployment	Mon 02/11/15	Wed 02/12/15	35
37		**Develop functional specs for each method**	**Mon 01/06/15**	**Tue 01/12/15**	
38		Functional specs drafted	Mon 01/06/15	Mon 31/08/15	
39		Review of draft specs by relevant stakeholders	Tue 01/09/15	Fri 30/10/15	38
40		Specs finalised and issued	Mon 02/11/15	Tue 01/12/15	39
41		**Identification of suitable suppliers**	**Wed 01/07/15**	**Fri 16/10/15**	
42		Engagement of procurement and supply chain	Wed 01/07/15	Fri 14/08/15	
43		Pre-qualification questionnaire prepared & distributed	Mon 17/08/15	Tue 15/09/15	42
44		Potential supplier list produced	Wed 16/09/15	Fri 16/10/15	43
45		**Testing of switching equipment**	**Mon 12/10/15**	**Thu 31/03/16**	
46		Potential suppliers engaged, incl. labs or similar test facilities readied	Mon 12/10/15	Tue 08/12/15	
47		Off grid simulations	Wed 09/12/15	Thu 04/02/16	46
48		Results obtained and analysed	Mon 08/02/16	Fri 25/03/16	47
49		SDRC 9.2 - Business case validation	Thu 31/03/16	Thu 31/03/16	
50		**Phase 1 final analysis**	**Mon 04/04/16**	**Mon 04/07/16**	
51		Internal presentation of results	Mon 04/04/16	Fri 15/04/16	
52		External disemination event with relevant stakeholders	Mon 02/05/16	Fri 13/05/16	
53		Consultation with all GB DNOs	Fri 27/05/16	Fri 17/06/16	
54		SDRC 9.3 - Phase 2 decision point	Mon 04/07/16	Mon 04/07/16	
55					
56					
57		**Phase 2: Task 1 : Deployment of Site Trials**	**Mon 04/07/16**	**Fri 21/12/18**	
58		**Procurement of equipment**	**Mon 04/07/16**	**Fri 07/10/16**	
59		Standard SEPD procurement process initiated	Mon 04/07/16	Fri 12/08/16	
60		Equipment procured	Mon 15/08/16	Fri 07/10/16	59
61		**Internal Systems integration**	**Mon 04/07/16**	**Fri 30/12/16**	
62		SCADA system integration work	Mon 04/07/16	Fri 30/12/16	
63		Communications testing with Real Time Systems team	Mon 05/09/16	Fri 30/12/16	
64		**Option 1 : Trial Installation**	**Mon 04/07/16**	**Thu 29/06/17**	
65		Preparatory works (RAMS, resourcing, scheduling)	Mon 04/07/16	Fri 05/08/16	
66		Install / test / commission of necessary equipment	Mon 04/07/16	Thu 29/06/17	
67		Review and lessons learnt fed-back for future sites	Mon 04/07/16	Thu 29/06/17	
68		**Option 2 : Trial Installation**	**Mon 04/07/16**	**Thu 29/06/17**	

ID		Task Name	Start	Finish	Predecessors
69		Preparatory works (RAMS, resourcing, scheduling)	Mon 04/07/16	Fri 05/08/16	
70		Install/test/commission of necessary equipment	Mon 04/07/16	Thu 29/06/17	
71		Review and lessons learnt fed-back for future sites	Mon 04/07/16	Thu 29/06/17	
72		**Option 3 : Trial Installation**	**Mon 03/10/16**	**Fri 29/09/17**	
73		Preparatory works (RAMS, resourcing, scheduling)	Mon 03/10/16	Fri 04/11/16	
74		Install / test / commission of necessary equipment	Mon 03/10/16	Fri 29/09/17	
75		Review and lessons learnt fed-back for future sites	Mon 03/10/16	Fri 29/09/17	
76		SDRC 9.4 - Initial learning from trial installation and integration	Fri 01/09/17	Fri 01/09/17	
77		**Decommissioning**	**Mon 02/07/18**	**Fri 21/12/18**	
78		Preparatory works (RAMS, resourcing, scheduling)	Mon 02/07/18	Fri 27/07/18	
79		Removal of necessary equipment	Mon 02/07/18	Fri 09/11/18	
80		Disposal / stocking of decommissioned equipment	Mon 30/07/18	Fri 21/12/18	
81					
82		**Phase 3: Task 1 : Monitoring & Analysis of Trial Sites**	**Mon 01/08/16**	**Fri 27/07/18**	
83		**Install network monitoring equipment**	**Mon 01/08/16**	**Fri 30/12/16**	
84		Install / test / commission of necessary equipment	Mon 01/08/16	Fri 30/12/16	
85		Review and lessons learnt fed-back for future sites	Mon 21/11/16	Fri 30/12/16	
86					
87		**Install transformer monitoring**	**Mon 03/10/16**	**Fri 21/07/17**	
88		Preparatory works (RAMS, resourcing, scheduling)	Mon 03/10/16	Fri 21/10/16	
89		Install / test / commission of necessary equipment	Mon 03/10/16	Fri 21/07/17	
90		Review and lessons learnt fed-back for future sites	Mon 28/11/16	Fri 21/07/17	
91					
92		**Data collection & analysis**	**Mon 03/04/17**	**Fri 30/03/18**	
93		Processes defined for obtaining & analysing data	Mon 03/04/17	Fri 19/05/17	
94		Manual / automated data collection & analysis	Mon 03/04/17	Fri 30/03/18	
95		Refinements fed-back acc. to experience	Mon 03/04/17	Fri 30/03/18	
96		SDRC 9.5 - Monitoring and analysis	Fri 22/12/17	Fri 22/12/17	
97					
98		**Validation of chosen trial sites**	**Mon 01/01/18**	**Fri 27/07/18**	
99		Comprehensive analysis of monitored data	Mon 01/01/18	Fri 27/07/18	
100		Comparison of predicted vs. actual performance	Mon 01/01/18	Fri 27/07/18	
101		Feedback to improve decision tool, site deployment etc.	Mon 01/01/18	Fri 27/07/18	
102		SDRC 9.6 - Site performance to date	Fri 30/03/18	Fri 30/03/18	

ID		Task Name	Start	Finish	Predecessors
103		**'Environmental' monitoring**	**Mon 03/10/16**	**Fri 29/06/18**	
104		Preparatory works (RAMS, resourcing, scheduling)	Mon 03/10/16	Fri 29/06/18	
105		Install / test / commission necessary equipment	Mon 03/10/16	Fri 29/06/18	
106		Review and lessons learnt fed-back for future sites	Mon 03/10/16	Fri 29/06/18	
107					
108		**Phase 3: Task 2 : Dissemination**	**Thu 01/01/15**	**Fri 29/03/19**	
109		**Develop dissemination/communications plan**	**Wed 01/04/15**	**Fri 03/07/15**	
110		Plan developed in-line with SEPD governance	Wed 01/04/15	Fri 03/07/15	
111		Communications manager engagement	Wed 01/04/15	Fri 29/05/15	
112					
113		**Establish & maintain project website**	**Thu 01/01/15**	**Fri 28/12/18**	
114		Prototype website built and reviewed	Thu 01/01/15	Fri 31/07/15	
115		Website maintenance schedule written	Wed 01/04/15	Fri 08/05/15	
116		Continuous improvement / project updates	Wed 01/04/15	Fri 28/12/18	
117					
118		**Organise project events**	**Thu 01/01/15**	**Fri 28/12/18**	
119		Project events schedule established (incl. conferences etc.)	Thu 01/01/15	Fri 29/05/15	
120		Event feedback incorporated into programme / tasks	Wed 01/04/15	Fri 28/12/18	
121		Event success criteria defined and monitored	Wed 01/04/15	Fri 28/12/18	
122					
123		**Project evaluation and assessment**	**Thu 01/01/15**	**Fri 28/12/18**	
124		Internal project analysis structure defined	Thu 01/01/15	Fri 27/02/15	
125		External feedback captured	Wed 01/04/15	Fri 28/12/18	
126		Continuous improvement/refinement based on evaluation	Wed 01/04/15	Fri 28/12/18	
127		SDRC 9.7 - Network losses evaluation tool	Fri 28/12/18	Fri 28/12/18	
128					
129		**Project Reports**	**Thu 01/01/15**	**Fri 29/03/19**	
130		Responsibility matrix developed wrt authoring, review etc.	Thu 01/01/15	Fri 27/02/15	
131		Lessons learnt utilised from previous projects	Mon 23/02/15	Fri 03/04/15	
132		Report review, update and finalisation programme defined	Wed 01/04/15	Tue 12/05/15	
133		SDRC 9.8 - Project closedown report provided and presented to Ofgem	Fri 29/03/19	Fri 29/03/19	
134					
135		SSE Comms Management	Wed 01/04/15	Fri 28/12/18	
136		Project Management	Thu 01/01/15	Fri 28/12/18	

SSET207 – LEAN Appendix 5 - Carbon and Financial Benefits

Key

Method	Method name
Method 1	LEAN Method 1 Option 1
Method 2	LEAN Method 1 Option 2
Method 3	LEAN Method 1 Option 3

SSET207 LEAN – Financial Benefits

Financial benefit (£m)								
Scale	Method	Method Cost	Base Case Cost	Benefit			Notes	Cross-references
				2020	2030	2050		
Post-trial solution (individual deployment)	Method 1 – Opt 1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	Benefits depend upon:1 – transformer losses, once validated, 2 – Actual site load profiles Average benefits taken from business case calculations – these will be validated in Phase 1 of the LEAN project.	Base case cost equals the value of losses saved over a 45 year period Individual benefits averaged from Licensee Scale results, below
	Method 1 – Opt 2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		
	Method 1 – Opt 3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		
Licensee scale **If applicable, indicate the number of relevant sites on the Licensees' network.**	Method 1 – Opt 1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	(Number of relevant sites: Option 1 = 136 Option 2 = 112 Option 3 = 21)	Data taken from Business Case
	Method 1 – Opt 2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		
	Method 1 – Opt 3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		
GB rollout scale **If applicable, indicate the number of relevant sites on the GB network.**	Method 1 – Opt 1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	(Number of relevant sites: Option 1 = 1416 Option 2 = 1166 Option 3 = 219)	Data taken from Business Case
	Method 1 – Opt 2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		
	Method 1 – Opt 3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		

SSET207 LEAN – Carbon Benefits

Capacity released (kWh)

Scale	Method	Method Cost	Base Case Cost	Benefit 2020	Benefit 2030	Benefit 2050	Notes	Cross-references
Post-trial solution (individual deployment)	Method 1 – Opt 1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	Benefits depend upon: 1 – transformer losses, once validated, 2 – Actual site load profiles	Base case cost equals the value of losses saved over a 45 year period Individual benefits averaged from Licensee Scale results, below
	Method 1 – Opt 2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		
	Method 1 – Opt 3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		
Licensee scale **If applicable, indicate the number of relevant sites on the Licensees' network.**	Method 1 – Opt 1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	(Number of relevant sites: Option 1 = 136, Option 2 = 112, Option 3 = 31)	Data taken from Business Case spreadsheet <LOSSES> tab
	Method 1 – Opt 2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		
	Method 1 – Opt 3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		
GB rollout scale **If applicable, indicate the number of relevant sites on the GB network.**	Method 1 – Opt 1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	(Number of relevant sites: Option 1 = 1416, Option 2 = 1166, Option 3 = 323)	Data taken from Business Case spreadsheet <LOSSES> tab
	Method 1 – Opt 2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		
	Method 1 – Opt 3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		

SSET207 LEAN Appendix 5 – Further details on base case and method case estimates

Introduction

This appendix provides a review of work to date that has informed the benefits case in terms of both financial savings and carbon emissions reductions.

Context

There are 461 primary substations in SEPD's licensed territory. Of these, the majority are operated at 33/11kV, with others working at 22/6.6kV and 33/6.6kV.

The LEAN project business case was developed using SEPD's data for 33/11kV substations. This was done because of a lack of readily available date on the fixed and variable (iron and copper) about some of the older transformers. The effect of the limitation in available data is likely to mean that the business case has excluded some of the key sites where each of the three the LEAN options would result in an enduring reduction in annual losses and carbon emissions.

The initial review of SEPD's 33/11 substations identified the 'peak load factor' (ratio of average to peak demand) for each site. This showed that, for many sites, the average load is less than 50% of the peak demand at that site, as shown in the graph, below, which is taken from an analysis of the substations in the SEPD Long Term Development Statement:

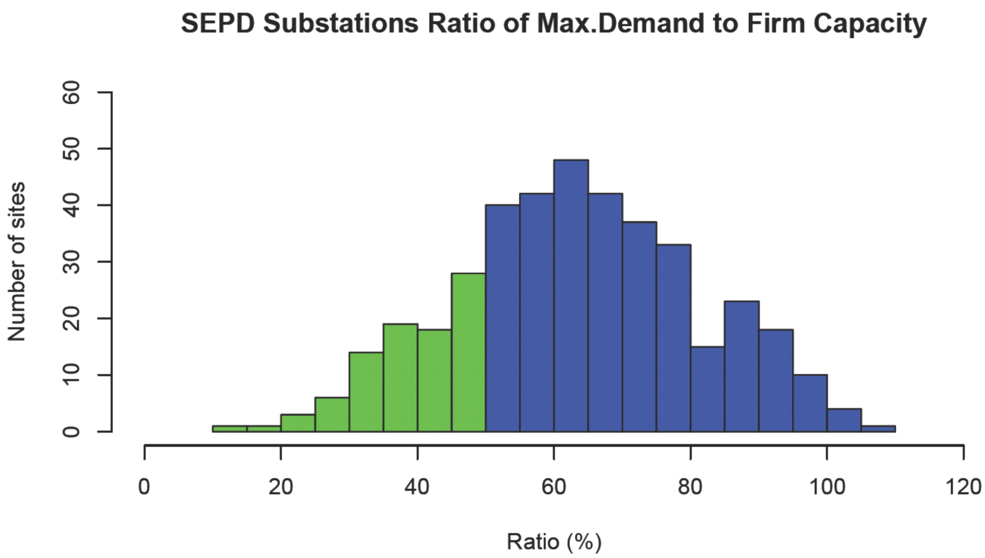


Figure 1 Graph depicting varying load factor in primary substations

LEAN project will re-evaluate transformer iron and copper losses on a selection of existing SEPD transformers.

For most transformers, the manufacturers have designed the core and windings so that the copper and iron losses are roughly equal at 50% of full load. Some transformers are 'dual-rated' with a continuous emergency rating (CER): these may have been designed and manufactured such In almost all of these substations, firm capacity is delivered through the deployment of two equally sized transformers, so that a site with 20MVA firm capacity has two 20MVA transformers installed. This means that, even for a site where maximum demand is the same as firm capacity (100% load factor) each transformer is only 50% loaded such that one transformer can continue to meet all demands should the second transformer fail.

Transformer losses are comprised of fixed (or iron) losses and variable (copper) losses. The fixed losses remain roughly constant whenever the transformer is energised and represent magnetising losses in the iron core. The variable losses occur due to the heating effect of electric currents in the copper (or aluminium) windings so that the copper losses increase according to the square law ($W = I^2R$).

Transformer losses are set by design and manufacture and are generally confirmed during installation and commissioning tests when the transformer is new and first installed on site. It is understood that ageing effects may cause an increase in iron losses, possibly due to deterioration in the core caused by overheating, over-voltage or high-current stresses during an adjacent fault [references: DOBLE paper[1] and ALSTOM NPAG[2] guidebook). For this reason, the copper losses are roughly equal to the iron losses at 25% of full load.

Each site is also exposed to variations in annual load, with a typical load duration curve reproduced here:

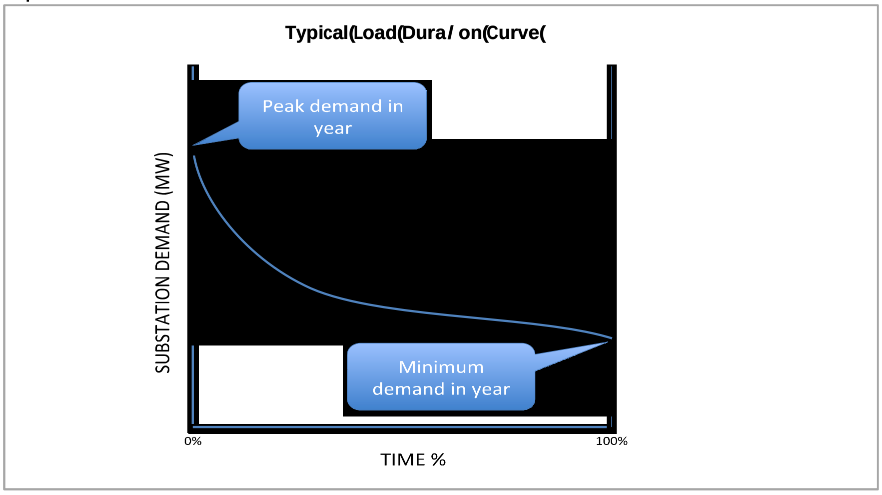


Figure 2 Depiction of typical load duration curve

The load duration curve confirms that, for typical SEPD substations, the peak demand is only present for a few hours in each year and there are long periods when site demand is less than 50% of peak and losses can be reduced via the LEAN method.

Each of the three LEAN options represents a different means of de-energising transformers.

OPTION 1: Deploy automation to de-energise transformers using existing switchgear.

OPTION 2: Deploy automation to de-energise transformers using advanced controls to minimise transformer inrush currents.

OPTION 3: Deploy advanced switchgear to de-energise transformers to minimise transformer inrush currents where necessary.

For each site modelled in the spreadsheet, the opportunity for losses reduction has been made by comparing total losses for single and dual transformer operation during each half-hour in a year. For simplicity, the spreadsheet made use of a single substation load profile that is considered representative of most sites within SEPD. Almost all of SEPD sites are associated with domestic demand so that this approximation is not expected to distort results by any significant factor.

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[1] MAGNETIC CORE ISSUES IN POWER TRANSFORMERS AND THEIR DIAGNOSTICS, W. F. Griesacker, J. L. Thierry Doble Engineering Company

[2] ALSTOM Network Protection & Automation Guide, Section 16.2.6: A conducting bridge across the laminated structures of the core can permit sufficient eddy-current to flow to cause serious overheating. The bolts that clamp the core together are always insulated to avoid this trouble. If any portion of the core insulation becomes defective, the resultant heating may reach a magnitude sufficient to damage the winding. The additional core loss, although causing severe local heating, does not produce a noticeable change in input current and could not be detected by the normal electrical protection. However it is important that the condition is detected before a major fault has been created.

Option 1 may be most appropriate where existing switchgear includes remote control functionality so that automation can be arranged either locally (at the substation) or centrally (at the SEPD control centre) and there are few switching operations required in any year. The LEAN project will trial this option and report on any impact to customer quality of supply or asset lifetimes.

Option 2 will enable the deployment of advanced local controls in order to minimise any inrush currents that can occur during transformer energisation which may be important if there are many switching operations required each year. The LEAN project will include trials of this option and report as for option 1.

Option 3 will be appropriate where there is no existing switchgear suitable for transformer energisation. The cost of suitable switchgear means that the LEAN method may only be cost-effective at about 5% of primary substations. The LEAN project will report as above on this and on the incremental cost of advanced switchgear over the cost of any planned replacement of traditional switchgear that may also result in a cost-effective deployment at some sites.

The three options involve increasing levels of capital investment. In consequence, the benefits that can be achieved are compared with the estimated cost of each option in order to identify those sites where a selected option will deliver a positive benefit.

Comparison of the long-term benefits with the estimated cost of each option has resulted in an estimate of the number, and value, of possible deployments for each option; these are listed in the LEAN business case spreadsheet for a sample set of SEPD's 33/11 transformers.

GB Wide Cost Benefit Assessment	Option 1	Option 2	Option 3
GB total number of sites	4800		
% of sites viable for LEAN	30%	24%	5%
GB sites for Option Modifications - pro rata	1416	1166	219
Total Investment [£]	[redacted]	[redacted]	[redacted]
Gross Benefit [£]	£65,551,040	£61,743,388	£23,002,922
45-Year Savings NPV [£]	1,521,079	1,432,732	533,768
45-Year Losses Savings [MWh]	306,773	288,948	107,641
45-Year CO2 Savings [ktCO_2e]	**£49,056,635**	**£46,207,091**	**£17,214,768**

Figure 3 GB cost benefits assessment of LEAN deployment

The savings to be achieved through the deployment of each option are dependent on the estimated costs of their deployment; the estimation of these savings is based on best estimates of rollout deployment costs compared with average per-site savings. The LEAN project will validate these costs as well as the savings to be achieved.

The application of each of the LEAN method options will maintain the security of supplies to customers within that required by Licence Condition (and as referred to in Engineering Recommendation P.2/6. In order to further enhance security of supply and to further reduce network losses, albeit by a small increment, Alternative Network Topology (ANT) will be trialled as an augmentation of the LEAN method. ANT will make use of existing 11kV feeder automation schemes to enable 'LEAN substations' to operate in parallel with a neighbouring substation.

The carbon emissions for producing the equivalent amount of electricity are calculated based on the UK average generation mix, which has carbon emissions of 428 g/kWh(e) (OFGEM: ‘Electrical distribution system losses: non-technical overview’, Mar 2009).

SSET207 LEAN Appendix 6 – Project Risk Register

	Description	Existing Controls	Likelihood	RISK	Mitigation / Contingency	Actions / Status	Residual Likelihood	Residual RISK
Work Package 1 – Project Management								
1	Resourcing the LEAN Project internally to SEPD	Future Networks Recruitment Procedure	Remote	L	Project manager allocated to the project should the bid be successful. Project engineer role defined and early engagement with SEPD resources started.	Arrange FN Recruitment Procedure to be initiated before the Decision Date; provide HR with advance requirements of Resource	Remote	L
2	Difficulties with supplier recruitment	Standard SSE procurement process	Remote	H	Contact to be made with potential suppliers to confirm interest in the project at this pre bid stage.	Contract negotiations to start immediately after the positive decision date, again escalation procedure up to ISB available	Remote	L
3	Lack of budget to complete project and over spend on budget;	FN procedure PR-PS-FNP-001	Occasional	M	Regular meetings and workshops with project suppliers; build up the costs via bottom up approach target in relation to number of sites.	Project manager will have control of financial position throughout the lifetime of the project, overseen by the South Delivery Manager and internal review process	Remote	L
4	Difficulties with existing SEPD resourcing the additional work	A budget allowance has been made within the bid submission	Remote	M	Early engagement with the required departments is critical to make them aware of the project, the requirements and the potential additional workload	To date all the required departments expected to be involved in the project have been engaged. This engagement will need to be increased significantly should the bid be successful	Remote	L

	Description	Existing Controls	Likelihood	RISK	Mitigation / Contingency	Actions / Status	Residual Likelihood	Residual RISK
5	Managing outages in conjunction with the multiple business units	Existing SEPD process to request staff / outages via the control centre	Remote	M	Long term planning of the tasks required with early engagement to the various departments involved. Additional back up plans will be needed should the outages be cancelled due to storms / faults etc	Planning of the outages must take place 6 months before planned date.	Occasional	L
Work Package 2 - Pre-Trial Analysis & Testing								
1	Inadequate data for the initial modelling	SEPD store all necessary data within PI historian or as part of system planning requirements	Improbable	M	The role of the project engineer on the project is partly to be the link between the SEPD core business in order to acquire and validate the data required to perform detailed modelling on specific circuits.	Project engineer to be recruited Q1 2015 if bid is successful	Improbable	L
2	Initial learning from modelling does not match expected benefits	Follow LEAN milestones and SDRC targets; FN Knowledge Management W1-PS-FNP-012	Remote	M	The project will have break points set up - if the learning is that expected benefits cannot be met. This will go to internal review if necessary the project will be stopped.	The project manager will report on the status of the project modelling work throughout the work package. Should the project not be delivering the expected outputs a decision will be taken at director level in conjunction with the PM to stop further work.	Remote	L

	Description	Existing Controls	Likelihood	RISK	Mitigation / Contingency	Actions / Status	Residual Likelihood	Residual RISK
3	External contractors more expensive than expected	SEPD will use the standard Procurement procedure, with cost figures based similar figures from the IFI project work	Improbable	L	Early engagement with a number of suppliers to quantify the modelling capabilities and estimates of day rates etc will ensure the original estimates are accurate	Initial engagement held with previous contractor working on IFI project.	Improbable	L
4	Modelling results not accurate representation of network benefits	Internal review of results by Project Engineer in conjunction with project team	Occasional	M	In addition to the project team review the work will be reviewed by an internal SEPD expert within the system planning team	Further engagement with system planning required to ensure department is aware of workload in 2015 if the bid is successful.	Occasional	L
5	Cannot locate a suitable primary transformer or sufficient method to complete the transformer testing	Working together with a GB based transformer manufacturer or independent transformer expert.	Remote	M	Need to engage with a number of foreign test labs / manufacturers in order to have a fall back plan if GB based manufacturer cannot provide testing / analysis required	We have spoken with Brush Transformers and they want to work with us on the project. Further engagement is required here to define exactly the scope of that work, how, when and where it will happen.	Improbable	M
6	Off site testing considerably more expensive than predicted	SEPD will use the standard Procurement procedure, with cost figures based on previous experience in this area	Remote	M	Detailed work with industry experts to specify the most suitable testing that can be completed within the timeframe / budgets available	Industry expert to be appointed das part of WP 2	Improbable	L

	Description	Existing Controls	Likelihood	RISK	Mitigation / Contingency	Actions / Status	Residual Likelihood	Residual RISK
Work Package 3 - Detailed Site Selection & Functional Specifications								
1	Lack of existing network information on the chosen circuits could cause delays and inaccurate results	Planning engineering resource allocated to the project to support the Project Engineer	Very Unlikely	L	If required the data can be manually gathered through site visits / inspections etc or installation of monitoring equipment.	Initial engagement with the system planning department and the previous IFI project have demonstrated that the information all exists	Very Unlikely	L
2	Not enough suitable sites can be identified	Initial work has identified a significant number of suitable sites from an electrical perspective	Remote	L	The final number of trial sites may have to be reduced to be representative of the site selection work	To be reviewed throughout the work package	Remote	L
3	Switchgear equipment cannot meet the intended specification	The initial work has shown that there are a number of options available on the market at present	Occasional	M	Early engagement with switchgear suppliers to inform the market of our intentions	In June 2014 an expression of interest was sent to over 20 switchgear manufacturers explaining the project and intentions. We have had 5 positive responses in relation to providing this equipment.	Remote	L
4	TASS switching algorithm cannot be deployed within the timescales	Algorithm required is overly complex and will be deployed by switchgear manufacturer as part of the product	Occasional	M	Early engagement with switchgear suppliers to inform the market of our intentions	In June 2014 an expression of interest was sent to over 20 switchgear manufacturers explaining the project and intentions. We have had 5 positive responses in relation to providing this equipment.	Remote	L
5	Switching methods are more expensive than estimates	Significant time and engineering experience based on similar installations were used to predict the costs	Occasional	M	If the costs are significantly higher it may result in fewer site deployments for the trial stage	Intention is to receive feedback from suppliers in relation to cost estimates are a high priority part of this work package	Occasional	M

	Description	Existing Controls	Likelihood	RISK	Mitigation / Contingency	Actions / Status	Residual Likelihood	Residual RISK
Work package 4 - Deployment of Trials								
1	Risk of damaging network assets	Existing protection systems	Occasional	H	The purpose of WP 2 is to complete testing and analysis to ensure there is no adverse effect on the plant. In addition detailed monitoring equipment will be fitted to the transformers to provide early warning signs of failure.	Work has begun to date on specifications of the detailed monitoring. This will be completed at the start of this work package, however will continue to be monitored throughout the project.	Remote	M
2	Risk of customer interruptions	Modified protection schemes	Occasional	H	This will form a major part of WP 2/3 to understand how it is possible to implement the scheme with some minor modifications in order to mitigate the risk to that of a traditional network arrangement.	Initial engagement with SEPD protection experts has taken place with no significant barriers highlighted. Additional work throughout the entire project in this area will be required.	Remote	M

	Description	Existing Controls	Likelihood	RISK	Mitigation / Contingency	Actions / Status	Residual Likelihood	Residual RISK
3	Power quality problems affecting customers	Modified protection schemes	Probable	H	The project will complete detailed modelling on this subject and will install power quality monitoring equipment at different voltage levels to ensure customers supply quality is not adversely affected by the transformer switching.	This will be completed throughout the various work packages	Occasional	M
4	Installation of 33kV switchgear	SEPD network safety procedures	Very Unlikely	L	SEPD regularly performs this task - if unfamiliar kit is to be installed a new bespoke procedure will be created to account for the different connections / control / protection settings etc.	New procedure to be created if necessary during WP4	Very Unlikely	L
5	Existing staff unfamiliar with new transformer operating arrangement	Training will be held with control room / operational engineers to detail the project plans and specific site briefing notes will be created with these teams	Improbable	L	Additional signage / warnings will appear on site and on SCADA systems to illustrate transformer switching is in operation	Engagement with existing business departments required throughout the project	Improbable	L
Work Package 5 - Monitoring & Analysis of Trial Sites								

	Description	Existing Controls	Likelihood	RISK	Mitigation / Contingency	Actions / Status	Residual Likelihood	Residual RISK
1	Electric shock from installation of monitoring equipment on live network	SEPD network safety procedures	Very Unlikely	L	SEPD regularly performs this task - if unfamiliar kit is to be installed a new bespoke procedure will be created to account for the different connections etc.	New procedure to be created if necessary during WP4	Very Unlikely	L
2	Insufficient or inconsistent data returned to complete expected analysis	The project will install the precise monitoring equipment required to capture the data necessary	Very Unlikely	L	Data will be reviewed at multiple points throughout the project to ensure we have what is required to perform the analysis work	On going throughout the work package	Very Unlikely	L
3	Monitoring equipment cannot be installed in time to support trials; Delays to trials schedule and subsequent activities	Start installation as soon as possible; Monitor progress and employ additional resource if necessary	Improbable	L	Initial monitoring installed in WP2 and additional kit installed at trial sites in WP4	On going throughout the previous work packages	Improbable	L
4	Failure in data management system; Loss or corruption of data	Trials are designed to repeat in cycles so that loss of one trial cycle doesn’t affect overall validity of project results	Improbable	L	Data will be collected in stages and stored securely on SEPD IT systems to ensure the chance of loss or corruption is as low as possible	Ensure disaster recovery plans are in place and fit for purpose.	Improbable	L
Work package 6 - Knowledge Dissemination								

	Description	Existing Controls	Likelihood	RISK	Mitigation / Contingency	Actions / Status	Residual Likelihood	Residual RISK
1	Inadequate resources to meet OFGEMs reporting and learning events	Employ academic support in this area, with expert/SEPD supervision	Improbable	M	The focus of the work will be complete by the SEPD project tem with support from the Academic institutions	Engagement with multiple academic institutions will be pursued during Q3/Q4 2014	Improbable	M
2	Inadequate Quality of Close down reports	Follow SEPD Knowledge Learning procedure	Remote	M	SEPD has significant experience in this area and has not yet missed an Ofgem target relating to learning reports for LCNF projects	Follow SEPD Knowledge Dissemination procedure	Very Unlikely	L
3	No access to the ENA portal and web sites	Carry out some pilot inactions with the software and hardware	Very Unlikely	L	Support from SEPD Future networks IT experts	Trial in advance of starting project	Very Unlikely	L
4	Outputs from potential academic support not clearly defined in relation to costs	Existing SEPD procurement process to define scope and objectives	Remote	M	Role of potential academic support will be clearly defined in an efficient and effective manner with key deliverables against delivery milestones.	To be reviewed at procurement stage	Improbable	L

No.	Descriptor	People	Environment	Asset	Reputation
6	Catastrophic	> 10 •Fatalities •Serious Disability •Life Threatening Health Effect	•Release to Sensitive Receptor •Damage outside SSE boundary •Permanent Loss of Sensitive Receptor	•Destruction of Entire Asset •Cost > £100,000,000 •Cost > 96% Budget	•International Media Coverage •International Political Reaction
5	Severe	4-9 •Fatalities •Serious Disability •Life Threatening Health Effect	•Release to Sensitive Receptor •Damage outside SSE boundary •Extensive Remediation resulting in Visible Change	•Destruction to > 25% Entire Asset •Disruption to Asset (< 3 years) •Cost < £100,000,000	•National Media Coverage •National Political Reaction •Investor Reaction
4	Major	1-3 •Fatalities •Serious Disability •Life Threatening Health Effect	•Release to Sensitive Receptor •Damage outside SSE boundary •Extensive Remediation •Multiple Breach to Operating Licence	•Damage to Key Operational Component •Disruption to Operation (< 1 year) •Cost < £10,000,000	•Regional Media Coverage •Regional Political Reaction •Organised Protest
3	Serious	•Serious Injury (reportable) •Lost Time Injury (>3 days) •Irreversible Health Effect	•Release to Sensitive Receptor •Slight localised damage outside SSE boundary •Easily Recoverable •Single Breach to Operating	•Damage to Major Item •Disruption to Operation (< 1 month) •Cost < £1,000,000 •Cost 36 – 55% Budget	•Prolonged Local Media Coverage •Local Political Reaction •Local Protest
2	Minor	•Minor Injury (medical treatment <3 days lost time)) •Reversible Health Effect	•Release to non sensitive receptor •Minor localised damage within SSE boundary •Recoverable	•Damage to Large Stock Item •Disruption to Operation (< 1 week) •Cost < £100,000	•Local Media Coverage
1	Incidental	•Slight Injury (first aid) •Slight Health Effect	•Release to non sensitive receptor •Slight localised damage within SSE boundary	•Damage to Small Stock Item •No Disruption to Operation •Cost < £10, 000	•Complaints From Neighbours

Figure 1 - Risk register severity analysis

		Likelihood					
		Very Unlikely	Improbable	Remote	Occasional	Probable	Frequent
		Never heard of in industry / work type	Heard of in industry / work type	Occurred within SSE	Occurs several times within SSE	Occurs on site	Occurs several times on site
Severity		A	B	C	D	E	F
Catastrophic	6	M	H	H	VH	VH	VH
Severe	5	M	M	H	H	VH	VH
Major	4	L	M	M	H	H	VH
Serious	3	L	L	M	M	H	H
Minor	2	L	L	L	M	M	H
Incidental	1	L	L	L	L	M	M
		10-6 - 10-5 /yr	10-5 - 10-4 /yr	10-4 - 10-3 /yr	10-3 - 10-2 /yr	10-2 - 10-1 /yr	>10-1 /yr

Figure 2 - Risk register severity vs likelihood guidance

7.0 Transformer Inrush Mitigation

7.1 Inrush Currents and Network Impact

Transformer energisation may result in inrush currents; these currents, according to [63], may cause "…adverse impacts on transformer itself (loss-of-life, mechanical damage to transformer winding) and power system operation (reduced power quality, mis-operation [or mal-operation] of protection devices and temporary overvoltages)." In addition, according to [63] again, the severity of the inrush currents "…largely depends on a number of parameters, including circuit breaker closing time, transformer core residual flux and core saturation characteristic, and network conditions."

For existing three-phase transformers where the LEAN TASS method may be applied, management of transformer constructional factors (such as saturation characteristics) or the external network conditions for the purpose of transformer inrush may be difficult or impracticable to effect. However, the influence of inrush current reduction or mitigation using controlled switching has been extensively studied in [64]-[68] and was demonstrated using ABB's Switchsync T183™ field tests in [69].

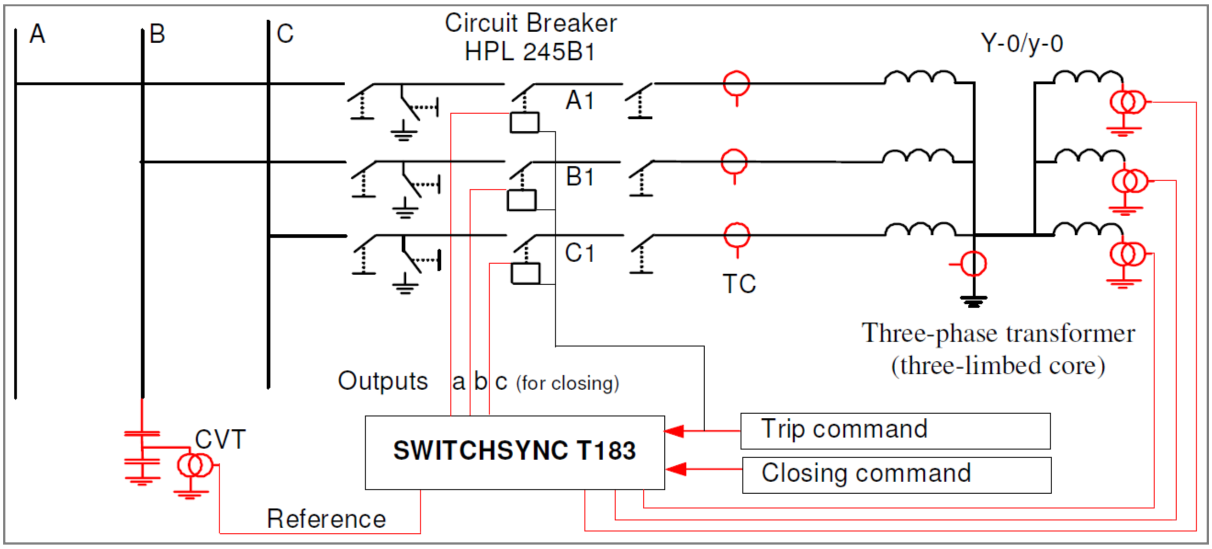


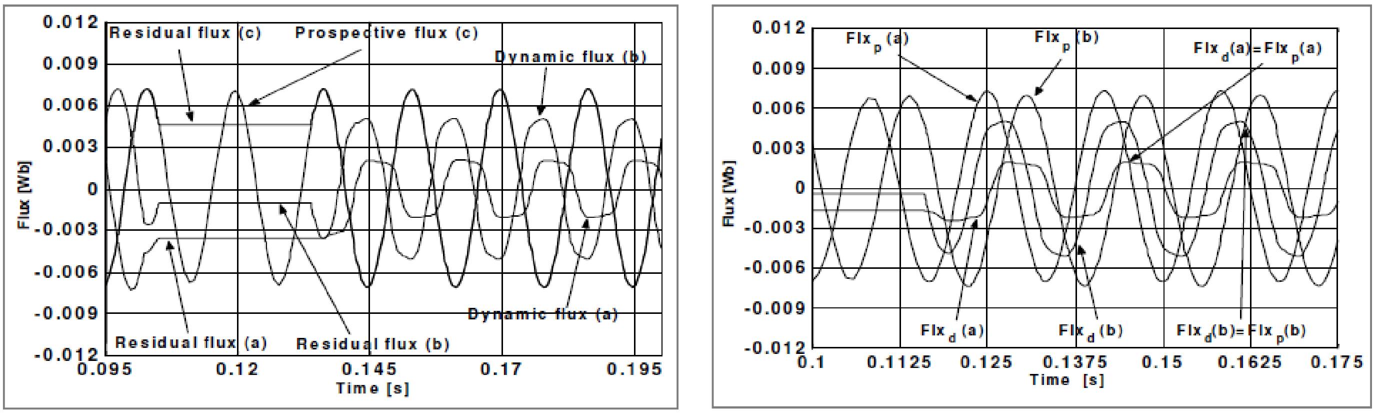
Figure 1 – ABB's Switchsync T183™ Application Schematic for No-Load Transformer Inrush Current Mitigation and Switching [69][70]

Complete Inrush Reduction or Elimination Strategy

"Transformers are generally energized by random closing of the circuit breaker contacts, with the system voltage being applied on the transformer windings at random instants," [69]. Reference [65] concludes that "If a transformer is energised at a random instant, it is possible that no transient inrush current will occur; but mostly transient inrush currents will arise. This happens because transient inrush currents depend not only on the instant of energisation, but also on the residual flux of the previous de-energisation."

"The basic principle for eliminating the magnetic over flux, or the asymmetrical flux appearing in the transformer core during its energisation, is to guarantee that the residual flux is equal to the presumable (or prospective) flux," [63]. According to [63] again, "a three-phase core type transformer has inherent interaction among the phase fluxes. In this type of transformer, after the first phase (or phases) energisation new fluxes are established throughout the open circuit legs." These are called dynamic fluxes.

To reduce transformer inrush currents, the optimal transformer switching instances, according to [63], are when prospective fluxes and dynamic fluxes are equal or coincide. This is illustrated in Figure 2.



a**. Core fluxes after Phase C is first switched ON** **b. Optimal instants for closing Phases A and B**

Figure 2 – Transformer Mitigation Strategy [63]

The strategy detailed in Figure 2 will require accurate knowledge of transformer fluxes following the de-energisation of a transformer; these are typically calculated online by continuously integrating the transformer primary or HV winding terminal voltages. The remnant or residual transformer flux is the flux when the de-energised transformer terminal voltage oscillations have completely decayed; however, the prospective fluxes calculations (as long as there is voltage at the supply side of the transformer energisation circuit breaker) are continued in the background following the transformer de-energisation. This allows for calculation of optimal transformer switching instances of time/angles on the voltage waveforms.

7.2 Sensitivities and Tolerances

For the purpose of transformer inrush mitigation, ideally, each circuit breaker switch phase pole should close at the exact calculated instance; however, due to uncertainty that exists within the mechanical switching mechanism of a circuit breaker, this is not always achievable in practice. Circuit breaker manufacturers typically specify a switching time and instance accuracy and tolerances for their equipment; for the purpose of transformer inrush mitigation. According to reference [65], "…a circuit breaker suitable for controlled switching of this transformer must have at most a closing time-deviation of 1.15 ms if no transient inrush currents should occur." Therefore, a circuit breaker pole switching time error tolerance of ±1 ms from the calculated optimal switching instance may be needed.

In addition, there may also be voltage sensor measurement and/or flux calculation errors that might impact the overall inrush mitigation algorithm's effectiveness in reducing inrush current to tolerable levels or elimination. According to [65], "the residual flux measurement device must have a minimum accuracy of 0.29 p.u. if an ideal circuit breaker is used". The allowable flux calculation error tolerances depend on the available headroom from the calculated Remnant to the flux saturation value.

7.3 Other Inrush Current Mitigation Methods

In addition to the described inrush current mitigation strategy in 7.2, additional strategies are also mentioned in [66]; these are listed below:

- **Rapid Closing Strategy**: This strategy closes one phase first and the remaining two phases within a quarter cycle. It requires knowledge of the residual flux in all three phases, independent pole breaker control, and a model of the transformers transient performance (no studies were run to compare transient performance of different transformer designs to determine error from assuming a standard model).

- **Delayed Closing Strategy**: This strategy closes one phase first and the remaining two phases after 2–3 cycles. It requires knowledge of the residual flux in one phase only, independent pole breaker control, but does not require any transformer parametric data.
- **Simultaneous Closing Strategy**: This strategy closes all three phases together at an optimum point for the residual flux pattern. It does not require independent pole breaker control, but requires knowledge of the residual flux in all three phases and that the residual flux magnitudes in two phases are high and follow the most traditional residual flux pattern.

7.4 Sensitive Earth Fault Protection

This section presents a brief description of the Sensitive Earth Fault (SEF) protection and possible alternatives that may avoid/prevent any mal-operations caused by circuit paralleling as part of Alternative Network Topology scheme.

7.4.1 Background

SEF protection is deployed by SSEPD on overhead 11 kV (MV) feeders, which include covered/insulated conductors – typically designated as "BLX". The use of SEF on BLX circuits remains a requirement of UK government Health & Safety or Engineering Inspectorate department, so that BLX may be deployed without any additional risk to the public.

SEF is intended to detect high impedance earth (ground) faults that typically occur when an overhead conductor is down on the ground.

More information on the SEF protection is available in the Alstom Network Protection & Automation Guide [71].

7.4.2 SSEPD Operational Policy Relating to SEF Protection

A review of SSEPD operational policy and practice is recommended, including the following aspects:

- Section of SEF trip settings;
- Selection of SEF time delays;
- Any mal-operation circumstances, including false-positives and false-negatives;
- Overall success/failure rate of detecting faults; and
- Comparison with any alternative protection schemes.

7.4.3 SEF Mal-operations due to MV Feeder Parallels

ESB Network's paper in [72] on faulted phase earthing (an alternative to Arc-Suppression Coil) reports that the "Single pole switching on a two phase spur may in some cases lead to mal-operation of protection even though there is no fault on the system."

It is assumed that a similar failure mechanism is responsible for any mal-operation on SSEPD's SEF protection schemes.

Possible Alternative Operating Policies:

It is not clear if 11kV feeder protection via SEF relay will require replacement. However, some possible alternative operating policies listed below are in no particular order.

- Alternative 1: Change existing SEF relay trip settings
    - o This is likely to represent the lowest-cost solution. While increasing the SEF relay setting will reduce its sensitivity to single phase loads and parallel feeder operations, it will also impair its reaction to high impedance earth fault scenarios. Any change to SEF relay settings will need to be reviewed with SSEPD protection team, particularly to ensure compliance with any Engineering Inspectorate / Health and Safety Executive (HSE) obligations. It is understood that SEF setting current is capped at 8 A and that this may

provide adequate sensitivity with stability for 11 kV feeder paralleling between different 33/11 kV substations.

- Alternative 2: Arc-suppression or Petersen coil earthing
  - An historic solution to single-phase overhead faults which can reduce/remove the risks to public. This is considered unlikely to fit SSEPD requirements due to consequential operational issues and CAPEX costs.
- Alternative 3: ESB Faulted Phase Earthing (FPE)
  - A recent ESB-approach to the protection of overhead circuits that may provide a suitable remedy. ESB Networks in [73] states that the "Sensitive Earth Fault (SEF) protection on the earthed neutrals is installed to detect and trip for high resistance earth faults. This existing system has the ability to detect single line to ground faults with a resistance of not more than 3 k• . The 20 kV network includes extensive two-phase sections resulting in a high level of capacitive unbalance on the 20 kV system. Single pole switching on a two phase spur may in some cases lead to mal-operation of protection even though there is no fault on the system."
  - Any use of the ESB FPE scheme would require thorough testing before deployment. Further details of the FPE scheme are included in the ESB paper [71].
- Alternative 4: Modern Relays:
  - There is High Impedance Fault (HIF) detection functionality in many modern electronic relays including [74]:

7.4.4 Conclusions and Recommendations

It is possible that any mal-operation of SEF relays due to short or long-term MV feeder paralleling may be avoided by adjustment of these relays settings; however, this may reduce the effectiveness of the SEF protection scheme.
There are also a number of alternatives to SSEPD's existing SEF relays and a review of these may reveal opportunities to improve on existing protection practices.

- Confirm SEF use at SSEPD including operational policy, including experience of mal-operations.
- Identify any opportunity to modify SEF relay settings so as to avoid mal-operations without adversely impacting SEF effectiveness.
- Confirm attractiveness of any alternative options with SSEPD, including HSE conformance.
- Identify opportunity to investigate and trial alternatives where these offer enhanced functionality at an affordable cost.

7.5 Power Transformer Monitoring

7.5.1 Advanced transformer monitoring

While power transformers usually exhibit long service lives of up to 60-70 years [77], there are occasions when deterioration of one or more of its components can lead to premature failure. As a result, there is now a range of in-service monitoring equipment available to assist in the identification of incipient failure.
Currently available on-line monitoring technologies are listed below:

- Gas-in-oil analysis (e.g. [redacted] advanced monitoring for power transformers [redacted] The detection of dissolved gasses in transformer cooling oil can help with the identification of an incipient failure including providing the opportunity of identifying the failure mode. Such on-line devices are regularly installed on high-value assets or where failure may involve high costs. It is also possible to arrange off-line dissolved gas analysis (DGA) of oil samples where sampling periods can be limited to months or years.

- Partial Discharge monitoring (e.g. [redacted] transformer partial discharge monitor). Detection of small electrical discharges within the transformer windings can be effected and provide early indication of failure.
- Performance monitoring (e.g. [redacted]

Dynamic monitoring of transformer thermal performance can assist with the identification of thermal issues, including incipient failures where these involve overheating of transformer components. The LEAN project will review the availability of monitoring devices appropriate for the project such that any deterioration in asset life can be identified, investigated and included in the project report.

APPENDIX 8: Technical background

8 Losses Reduction Opportunities – A Review from a Utility's Perspective

8.1 Losses Reduction Management and Policy

Utilities' electrical losses management and policies are driven by internal and external factors; such as electricity distribution assets and transport efficiency [13][14], cost of electricity supply to customers [22], sustainability efforts (accounting for economic, social, and environmental factors)[9][16][17], etc.

External factors include complying with statutory obligations, local and international standard bodies, and industry regulators. The internal factors include aspects that will bring best value to their shareholders, stakeholders (e.g. customers), industry, etc. These policies drive both non-technical and technical approaches to electrical losses reduction.

A wide variety of non-technical utility losses reduction approaches (direct or indirect) are employed today. These include education and training of utility staff, customers, and general public in the use of electricity and practical ways to reduce consumption [23]; improve efficiency [13][14]; promotion of sustainability and environmental conservation [23][24]; rising awareness of related utility service offerings to customers [25]; implementation of low losses asset procurement strategies [13][14]; etc.

Technical utility losses reduction approaches, according to reference [26], are grouped as operations, design, major development projects, and network reinforcements.

- Operations: Operational losses reduction measures include utilisation of optimal feeder sectionalising, conservation voltage reduction, de-energisation of under-utilised distribution transformers, Alternative Network Topology (or network meshing), capacitors or custom power device based reactive power compensation, energy storage, etc.
- Design: This includes economic sizing of overhead conductors and underground cables, procurement of low loss transformers, etc. Utilisation of some of these approaches by the DNOs in the UK are either mandatory or are likely to become mandatory in the future [13]-[15].
- Network reinforcements: About 2/3rd of feeder losses arise in the first 1/3rd of main feeder lengths; upgrading such sections can be extremely cost effective [26]. Application of additional strategies, such as strategic installation of capacitors or custom power device based reactive power compensation, energy storage, etc., reduce the need for short-term network reinforcements; these strategies may also help with the overall network electrical losses reduction.

8.1.2. Feeder Tie Open Point Optimisation

Optimal feeder sectionalising, or load balancing between feeders, is among the cheapest of electrical losses reduction measures [26]. This is currently achieved by the DNOs in the UK by the movement of 11kV feeder open points assessed using internal power flow studies and engineering judgement, accounting for variation in seasonal load and load growth.

Currently there are no examples in the UK where this is implemented to dynamically reconfigure the network (e.g. every half hour) through a centralised (or local) losses reduction optimisation algorithm; however, similar schemes in combination with other network aspects are proposed in existing literature (e.g. studies in [27]-[29]).

SEPD commissioned studies in [19] have shown that a dynamic tie open-point optimisation scheme, when solely implemented for the purpose of network losses reduction, may be expensive and may have limited return on investment. This is due to tie open-point circuit breakers wearing out often, and therefore, requiring the utility to replace circuit breakers every few years. The low return is also a corollary of the point mentioned above, that about 2/3rd of feeder losses arise in the first 1/3rd of main feeder lengths.

8.1.3 Conservation Voltage Reduction

According to 2010 US Depart of Energy's Smart Grid report in [30], "End-use energy consumption has been shown to drop when the electric service voltage is reduced. This strategy, termed conservation voltage reduction (CVR), occurs primarily because the energy consumption of certain end-use loads such as incandescent lights and certain electronics go down as the voltage is decreased."

A comprehensive field study in [31] involved 31 feeders at 10 different substations and 11 utilities in the Pacific Northwest. The study showed that a 1% change in distribution line voltage provided a 0.25% to 1.3% change in the end-user energy consumption, and that voltages could be reduced from 1% to 3.5%. In addition, it has been also reported in [32] and [33] that the CVR scheme, when applied universally in the US, could deliver a 2% reduction in 2030 electricity demand.

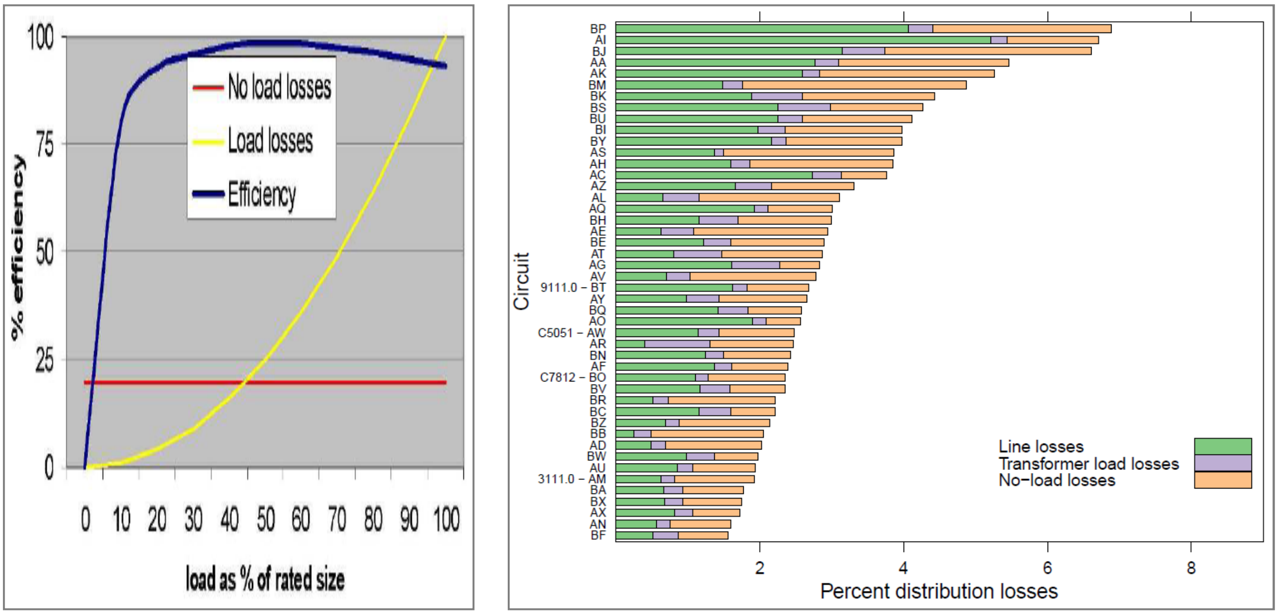
However, according to reference [30], "Accurate determination of the CVR effects on any given feeder must include analysis of the electrical load as well as the design of the distribution system. The design of the distribution feeders includes everything from line and cable types, line and cable configurations, use of voltage correction capacitors, and use of tap-changing voltage regulators for transformers. Thus, extrapolating the CVR results to estimate the national potential is difficult."

An ESB Networks published paper in [33] has identified a CVR factor (dP/dV) of 0.35 for domestic load that consisted of significant refrigeration and lighting. It is relevant to note that, at the time of this study, the majority (around 92%) of domestic lighting identified by ESB Networks was incandescent rather than CFL or LED, neither of which are voltage dependent. While there may be an improvement in the refrigeration motor efficiency when operated closer to 230 V, the gross energy requirement to maintain a set refrigeration temperature will not change and annual energy demand is not expected to vary significantly. Recent refrigerator developments (in response to the EU Eco-Design Directive 2009/125/EC [14]) may include the brushless DC motor for enhanced efficiency over traditional shaded pole designs; such motors are likely to be supply voltage independent.

In addition, currently, there are no practical studies available to confirm the appropriate CVR factors for SEPD customer groups to quantify the benefits offered by the use of CVR scheme in the SEPD's networks.

8.1.4 Transformer Auto Stop-Start

Utility distribution transformers (ranging from tens of kVA to tens of MVA) typically have efficiencies higher than 98% [34]; the remainder of the transformer's transfer energy (i.e. less than 2%) is lost as transformer fixed (or iron) losses and variable (or copper) losses. The peak transformer efficiency, according to [34][35] and as detailed in Figure 10.1a, "…occurs when load loss and no-load loss are equal."



a. Trans. Efficiency with Load [34]   b. Feeder Losses Breakdown [36]

Figure 1 – Distribution Transformer Losses

For distribution transformers with primary voltage rating between 10 kV and 120 kV, the total (iron plus copper) loss ratio to transformer overall power rating may range between 0.12% to 0.4% and 0.8% to 2% respectively [35][58]; the ratio of iron to copper losses may, however, vary between 10% to 25% [35][58].

The new EU Eco-Design Directive [14][15], introduced in 2009, is expected to further reduce transformer losses on all new procurements; the iron to copper losses ratio for liquid-immersed type medium power transformers (i.e. • 3.15 MVA) is about • 10% and about • 20% for dry type. The minimum efficiency for both liquid-immersed and dry type large power transformers (i.e. >3.15 MVA) is greater than 99.2%.

In addition, operational transformers over their lifetime, due to down-feed feeder faults, transformer energisation due to uncontrolled switching, etc., may have un-faulted internal core damage. Damage may include shorting of laminations, disfigurement of laminations causing increased flux infringement, etc., leading to increase in transformer iron losses; this has been reported in [81].

Although, transformers are efficient at high load factors, the average annual load may be much lower, so that the copper losses are lower than the iron losses. This phenomenon (as detailed in Figure 10.1b) was observed in several feeder losses studies: SEPD commissioned 'Isle of Wight Network Losses Study' in [19], EPRI's 'KCP&L Green Circuits Analysis' in the USA [36], Power System Engineering, Inc. study in [37], etc. In Isle of Wight losses study in [19], for example, among nine 33/11 kV substations during the year 2012, five substations had load less than 40% of their firm capacity for about 95% of the time, two substations among the remainder had load less than 40% for about 40% of the time, and the remaining two substations had load less than 50% for about 40% of the time.

Switching off one of a pair of under-utilised distribution transformers was suggested in ESB Networks 1999 paper in [26]. The paper, i.e. [26], also suggests that, "Such switching is usually only practical in SCADA or remotely controlled stations, where the cost of carrying out the switching is minimal". Although, variants of Stop-Start schemes have been applied before to Arc Furnace switching applications [21], the Auto Stop-Start application described in the

LEAN project for the purpose of distribution transformer losses reduction has never been applied in the UK or elsewhere in the world.

SEPD's commissioned network losses reduction study in [19] has shown that significant losses reduction could be achieved using transformer Auto Stop-Start scheme; about 9% reduction in overall 11 kV network losses (with inclusion 33/11 kV primary and secondary LV transformer losses) could be achieved. The study assumed that the 33/11 kV substation transformer iron losses were about 17% of the copper losses which reflects international data (e.g. [58]).

8.1.5 Alternative Network Topology

The primary benefit of the Alternative Network Topology (also known as a network meshed topology) is the maintenance and/or improvement of network reliability. According to The Brattle Group report in [38], "… distribution systems are frequently radial in design, whereas transmission systems are normally meshed." Network meshed topologies are also typically applied to high load-density urban distribution networks, and radial topologies to lower load-density rural distribution networks.

In an urban meshed networks, according to [38], the "Network systems are designed with redundant supply paths, although lines to individual customer premises are typically stand-alone." This enables utility's personnel to visually identify the fault location, identify the best fault isolation switches, isolate the fault, and re-establish supply to customers. Although, the manual procedure to restore electrical supply is long, it reduces the number of customers without supply following a system fault.

The secondary benefits that are achieved using network meshed topology is reduction in an overall network impedance, and as consequence, according to [39][40], it reduces the overall network electrical losses, maintains higher fault levels, reduces voltage drop, improves overall power quality, etc.

With advancements in switching technology and new control algorithms (e.g. S&C's IntelliRupter® PulseClosers and IntelliTeam II® Automatic Restoration System [18][41][42], distributed automation using reclosers and sectionalizers [43][44]), networks are able to deploy co-ordinated distributed intelligence, enabling fast automated fault isolation and sectionalizing schemes; this significantly reduces the electrical supply restoration time following a fault. Some of these technologies are currently deployed as part of a technology demonstration project at the SEPD Isle of Wight region in the UK [18][45]. At the completion of the project pilot, SEPD in [18] has concluded that "…the technological benefits of pulseclosing and economic benefits of reducing CML were repeatedly demonstrated."

8.1.6 Reactive Power Compensation

"Power factor is the ratio between the useful (true) power (kW) to the total (apparent) power (kVA) consumed by an item of a.c. electrical equipment or a complete electrical installation" [46]. Ideally, a power factor of unity is desirable, "Anything less than one [unity power factor] means that extra power is required to achieve the actual task at hand" [46].

Where there are low power factors, DNOs sometimes install reactive compensation equipment to improve local or overall network power factor, which consequently reduces the network current flows. As "All current flow causes losses both in the supply and distribution system" [46], such installations may help reduce the network electrical losses.

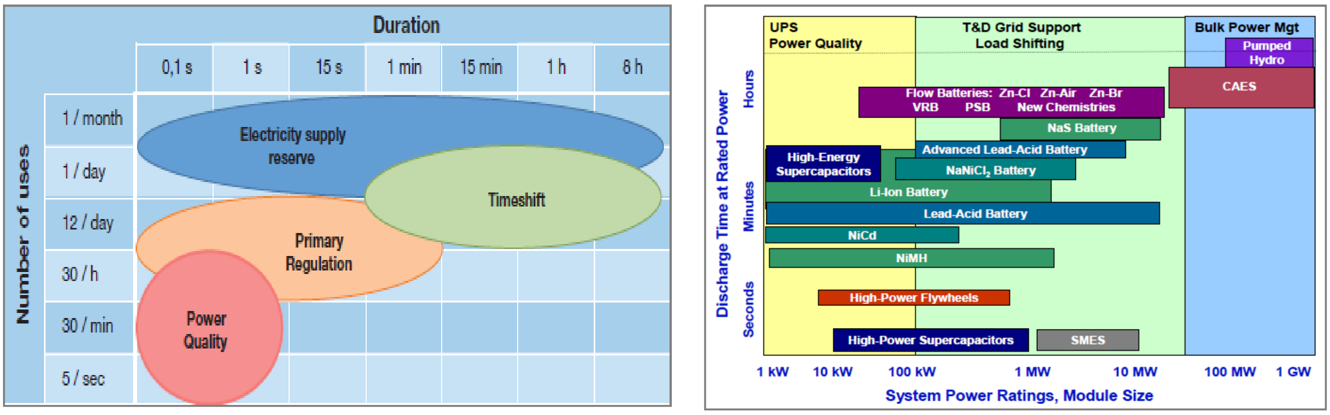
There is a variety of reactive power compensation equipment available today; they range from simple passive equipment to advanced customer power devices [47]. Deployment and control of these devices in the network could be local and standalone, or be part of the overall distribution network multi parameter (power factor, voltage profile, losses reduction, etc.) optimisation and co-ordinated control (e.g. use of CVR) [33][46]-[48]; the devices may also be placed strategically to enable such control (e.g. placement of distribution capacitors [49], DSTATCOMs [50], etc.)

Currently, the average power factor at SEPD substations is better than 0.96; the opportunity for the use of reactive power compensation to reduce network losses was therefore not been considered in SEPD commissioned network losses reduction study in [19] or further investigated.

8.1.7 Energy Storage

Currently, energy storage solutions are primarily employed to: provide fast frequency response support to the grid [46][52], act as a back-up supply to a site during loss of mains, reduce network reinforcements, enable grid stabilisation by accommodating distributed generation (e.g. wind and PV) [46][53], provide power flow peak shaving and congestion management [54][56], etc.

In addition, inverter interfaced grid-connection storage solutions can also provide additional services, such as reactive power compensation and voltage support [46], reduced losses via power flow peak shaving [54][56], improvement to power quality[46], etc. A review of existing electrical energy storage technologies, their applications and suitability is provided in Figure J.2.



a. Uses of Energy Storage in Grids [46]

b. Current Technologies and Capabilities [52]

Figure 2 – Electrical Energy Storage Applications

For the energy storage to be effective in power flow peak shaving application, which enables consequential reduction in electrical losses, some level of feeder load forecasting is needed. In practice, errors in load forecasting exist that may reduce the overall effectiveness/efficiency of storage application to power flow peak shaving. However, there are distribution load forecast algorithms that are employed currently in the US (such as EPRI's Artificial Neural Network Short Term Load Forecaster (ANNSTLF) [56]) that have shown to maintain the load forecast errors to less than 2%.

Furthermore, the reduction in electrical losses achieved using energy storage is typically a secondary function following fulfilment of it primary function; for example, as part of distribution active network management [55], power flow peak shaving, etc.

SEPD's commissioned network losses reduction study in [19] has shown that energy storage purely from an electrical losses reduction point is not cost effective.

8.1.8 Distributed Generation

Embedded generation's impact on the local and overall network electrical losses depends on several factors, such as its proximity to load and level of consumption, spillage of excess generation to other network voltage levels, network circuit conductor sizes and selection criteria, etc.

Studies conducted by Strathclyde University for the Electricity Network Strategy Group on some of these aspects, as detailed in [28], show that the embedded generation may enable a reduction in losses when network load is greater than about 70% of its peak value.

SEPD's commissioned network losses reduction study on the Isle of Wight 11 kV network in [19] has shown that the embedded generation may increase overall 11 kV network electrical losses; however, the system wide electrical losses (400 kV to LV) may reduce.

8.1.9 Network Reinforcements

ESB Networks, which has been upgrading its MV network from 10kV to 20kV over the last 15 years [59], has reported in [33] that "The costs of 20kV conversion were little more than those of rebuilding in 10kV, yet the voltage drop was halved, thermal capacity doubled and losses reduced by 75%." Upgrade costs, for example, according to ESB Networks in [60], "From 2007 -'10 incl. the cost of the programme for renewing and upgrading existing network plus construction of new lines and transmission /distribution stations is in excess of €2.5 billion."

There is some history in the GB of network voltage upgrade work [61][62] – almost the entire earlier 6.6 kV underground network has been upgraded to 11 kV between the 1960's and the present date. In many cases, it was found to be economically 'fortunate' that the 6.6 kV cable was capable of reliable operation at 11 kV.

A network voltage upgrade can be expected to provide significant reduction in losses; while its deployment may be expensive, disruptive, and time consuming the benefits of an increase in capacity for new load and generation connections may suit the future low-carbon customer.

SEPD's commissioned network losses reduction study in [19] has shown that "Although, the intervention offers significant savings in network losses savings compared to any other considered intervention," and "the upfront high investment outweigh any cumulative benefits offered for remainder of the assessment period, with no expected ROI [Return On Investment]."

Appendix 7 & 8: Document References

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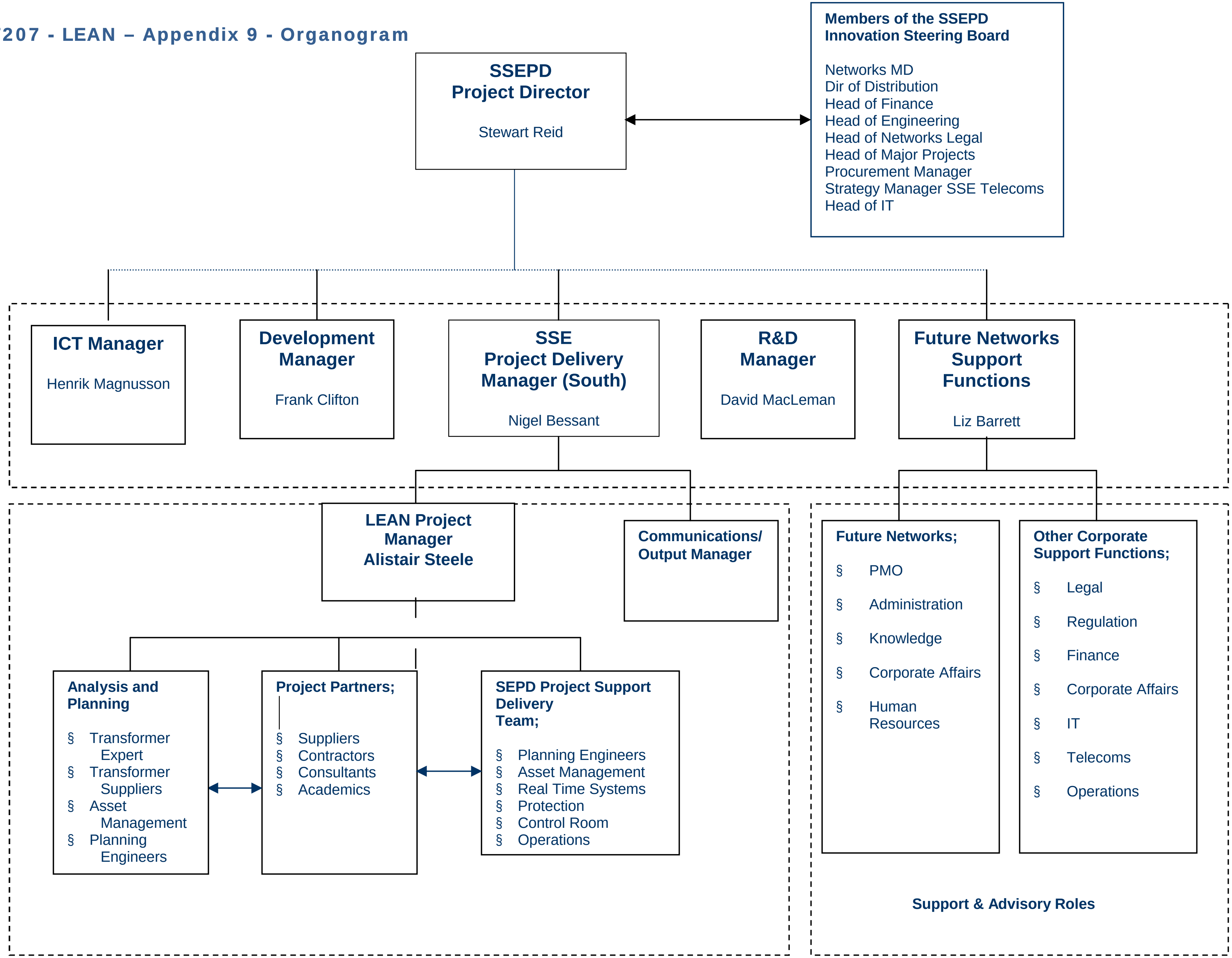
SSET207 - LEAN – Appendix 9 - Organogram



SSET207 - LEAN – Appendix 10 – Contingency Plan

Ref No.	Description	Existing Controls	Likelihood	RISK	Immediate Action	Interim Measures	Long Term Recovery
1	Lack of budget to complete project and over spend on budget;	FN procedure PR-PS-FNP-001	Improbable	M	Raise concerns of budget overspend at the monthly ISB meetings. Consider in detail any areas where cost savings could be made to keep the budget on track	Potentially need to complete a revised procurement process and review the scope of the contractors work. Additionally the number of trial sites may need to be reduced slightly.	Consider the possibility of further reducing project scope to fit budget
2	Initial learning from modelling does not match expected benefits	Follow LEAN milestones and SDRC targets; FN Knowledge Management work instruction 'W1-PS-FNP-012'	Remote	M	Completed a detailed review of the modelling results with an internal SEPD expert to determine the validity of the modelling and repeat sections if required	Consider reducing the number of sites based on the modelling results to ensure the trial is only applied to sites where the benefits case is positive	Stop the project at this point, collate the learning and do not proceed with the trial phase
3	Incorrect / inadequate data for modelling	A positive case depends heavily on transformer loss data	Improbable	M	Focus is required on this at early stage of project to visit sites, trawl through documents etc	Work closely with our system planning department to complete a detailed validation process for the data we have collated.	Stop the project at this point, collate the learning and do not proceed with the trial phase

Ref	Description	Existing	Likelihood	RISK	Immediate Action	Interim Measures	Long Term Recovery
4	Cannot locate a suitable primary transformer or sufficient method to complete the transformer testing	Working together with a GB based transformer manufacturer or independent transformer expert.	Remote	M	Raise the issue with ISB to see if a suitable transformer could be located in either network patch; north or south (SEPD or SHEPD)	Consider the possibility of utilising a foreign test laboratory to complete the required testing.	Ultimately we may need to transport a transformer to a suitable site which will increase the costs significantly
5	Switching methods are more expensive than estimates	Significant time and engineering experience based on similar installations were used to predict the costs	Occasional	M	Complete a revised procurement process to ensure the prices are as competitive as could be reasonably achieved within the timescales	Reduce the number of sites the equipment can be deployed at and revise the business case for the losses strategy	If the costs are so high that it is unlikely a positive business case can be achieved in the future the trial phase of the project will be halted
6	Risk of damaging network assets	Existing protection systems	Occasional	H	At the first sign of equipment degradation the switching methods (TASS) will be stopped across all sites immediately until further review	Significant analysis will be completed on the damaged asset and other trial sites. The system will not be turned on until it can be assured that the damage is not a result of TASS switching process	If it is confirmed that the TASS switching process is affecting the asset health in a detrimental manner the project will be stopped

Ref	Description	Existing	Likelihood	RISK	Immediate Action	Interim Measures	Long Term Recovery
7	Risk of customer interruptions	Modified protection schemes	Occasional	H	At the first sign of potential risk to customer supplies the switching methods (TASS) will be stopped across all sites immediately until further review. The project will use manual switching to restore supplies in less than 3 hours	Significant analysis will be completed on the affected site. The system will not be turned on until it can be assured that the TASS switching process is not to blame for the customer interruption	If it is confirmed that the TASS switching process is putting customer supplies at an increased risk the project will be stopped
8	Power quality problems affecting customers	Modified protection schemes	Probable	H	If the power quality monitoring shows the TASS switching is causing unwanted power quality issues for customers the system will be turned off until further review	A detailed study will be completed in order to understand the impact the TASS switching is having on the supply quality and what can be done to alleviate the problem	If the issues cannot be resolved the system will be altered significantly or the trials stopped
9	Inadequate resources to meet Ofgem reporting and learning events	Employ academic support in this area	Improbable	M	Issue will be raised at ISB to quantify the resourcing requirements and what can be done to resolve the issue	Additional internal resource will be given to the project to support the reporting from within the Future Networks team	Ultimately additional external resource could be contracted to meet the reporting requirements

SSET2 LEAN Appendix 11 - References

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Appendix 12 – LEAN – Phase One

12.1 Introduction

At the end of Phase 1 of the LEAN project, the project team will conduct an assessment of the methods' technical and economic viability; from this, SEPD will decide whether to proceed to Phase 2. This appendix provides information on the assessment process, and the information that will be used to make the decision.

12.2 The Assessment Process

The primary focus for Phase 1 is to develop a comprehensive and robust understanding of the costs, benefits and risks associated with the deployment of the LEAN method.

The criteria will be based on a model which compares the potential benefits against the sum of potential costs and risks. The financial model for each of the three options for TASS will be run against actual data gathered from reliable sources to verify the number of sites for which the method is applicable. The model will also take into account whether ANT also needs to be applied.

The criteria will take into account the costs of equipment procurement and risks to, and mitigation of, transformer health and supply quality. The mitigation actions proposed will be such that the level of risk is managed to ensure it is not greater than the current situation.

If the number of substations suitable for each option and the associated benefits provide a positive net present value, and provides benefits greater than the combined costs and risks of deployment (based on equipment costs and the cost of mitigation), whilst recognising the cost of the trials then that option will proceed to Phase 2. If the reverse is true, then that option will be discarded.

The data set used to run the financial model assessment consists of:

- A detailed assessment of the potential benefits available by application of the LEAN method based on the SEPD transformer portfolio further developed to reflect the benefits at GB scale. In the initial analysis, seen in Figure 2, the methodology used to calculate energy loss costs is based on SSEPD's RIIO:ED1 submission, which used a base figure of £48.42 per MWh. A similar methodology will be used in Phase 1.
- Detailed calculation of equipment costs required for the LEAN solution's deployment.
- Outputs of engagement with transformer specialists, which provide information regarding the possible effects on asset health and life, risks and the cost of mitigation.

For the project to proceed to Phase 2, the mitigating measures applied must reduce the level of risk such that it is not greater than the current situation. The cost of these mitigations will be included in the financial assessment. If the project demonstrates a positive NPV for its deployment, the project team will recommend that the project proceeds.

The outputs from Phase 1 of the project will be presented in the first instance to the Innovation Steering Board and then to the SSEPD Board, in line with the arrangements detailed in Section 6 of the full submission document. The project team will submit a recommendation as to whether the project should proceed to development. The outputs from Phase 1 will be shared with Ofgem and the other DNOs as appropriate.

12.3 Phase 1 Activities

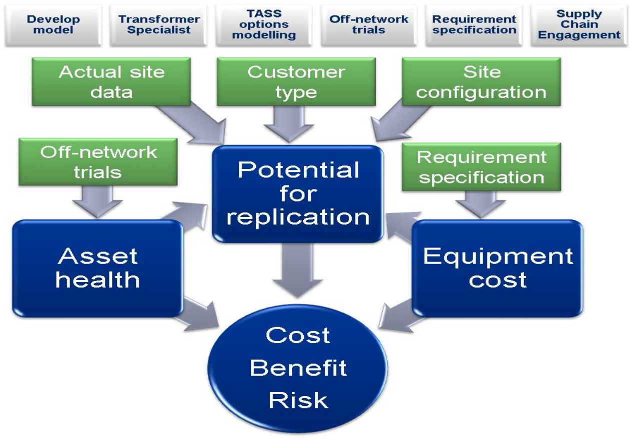

Figure 1: Overview of work activities to be conducted in Phase 1

The first phase of the project will incorporate a series of data modelling and analysis in addition to engagement with the supply chain, transformer specialists and other DNOs. The following list provides an outline of this work, which will inform the assessment process at the end of Phase 1 and ultimately, the decision of whether or not to proceed with LEAN.

Asset Health – Engagement

LEAN is an innovative approach to managing losses on the distribution network and has never been applied at scale. SEPD intends to seek guidance and input from a range of sources to inform the project business case prior to moving to deployment. This will include engaging with a range of other stakeholders, including:

i) DNO Engagement – This will include discussion with other DNOs to gain a comprehensive understanding of the GB transformer population and network configurations, to ensure that the analysis and modelling is representative of the GB network.

ii) Transformer Specialist – SEPD will procure advice from a recognised transformer specialist to help develop the LEAN project. The scope of works will include:

- Experience from other sectors and industries;
- International experience;
- Impact of additional switching operation;
- Impact on asset life;
- Impact on reliability;
- Monitoring strategy; and
- Interpretation of results.

One of the early activities will be to fully develop the requirements and procure the services of a transformer expert. A number of potential suppliers have already been identified.

iii) Transformer Manufacturers – SEPD will seek input from the existing range of suppliers of power transformers. This will focus on the potential impacts that a new operating regime could have on the transformers and duty cycle, especially any bearing on asset life or failure modes.

iv) Off-Network Trials – Prior to implementation, the project will deploy the equipment for each of the options along with the proposed measurement equipment on a transformer that is not connected to the network. This will allow a large number of switching operations to be done in a short period of time. The outcomes will be used to further assess the suitability of each of the options, give initial indication of impact on transformers and ensure that the monitoring strategy is appropriate.

Benefits – Loss Reduction Model / Potential for Replication

During Phase 1 SEPD will develop a more accurate and robust assessment of the potential benefits from the project.

i) Load Duration Curves - The loss reduction model is based upon detailed examination of the primary substation load duration curve and comparing it with the loss characteristics of the transformers to establish when it would be beneficial to switch off one in a pair of transformers.

In order to give an initial indication of the potential benefits available, the load duration curve from the Isle of Wight IFI project was used. This curve was then "flexed" to reflect the maximum demand at each site on the SEPD network. During Phase 1 the "actual" load duration curves for each of the SEPD sites will be used to populate the model.

(ii) Transformer Loss Characteristics - The initial assessment was based on the iron and copper losses recorded when the transformers were originally commissioned. During Phase 1, it is planned to repeat these commissioning tests to measure the actual losses occurring on the transformer. These tests will be carried out on a representative selection of transformers to validate that the recorded figures are accurate, but more importantly, to understand if the iron and copper losses have changed over the life of the transformer.

iii) Network Characteristics – Phase 1 will also see further development of the site selection criteria for LEAN. This will include consideration of network connectivity, customer types, customer numbers, PSR customers, environmental factors, sensitive loads as well as considering the practical and logistical aspects of deploying the equipment.

iv) Future Changes in Demand Patterns – Increasing volumes of distributed generation and proliferation of other low carbon technologies there is likely to be a change in demand patterns recorded at primary substations. This will potentially result in increasingly extreme highs and lows in demand, and more intermittent demand profiles with a lower overall utilisation factor.

The analysis will be based upon the detailed assessment of the SEPD transformer population which, when combined with the cost information detailed below, can be extrapolated to GB level to identify the number of sites which could produce positive benefits.

Costs – Equipment Costs
During Phase 1, the project team will continue to develop the assumptions around the cost of the project.

i) Requirements Specification – Following input from selected transformer specialists, manufacturers and DNOs, SEPD will develop a detailed requirements specification for appropriate equipment. This will include relays and new high specification switchgear, and may also include procurement of additional equipment such as enhanced breathers.

ii) Supply Chain Engagement - This requirements specification will be used to engage with equipment suppliers, validating the initial cost assumptions and ensuring that there is a robust and secure supply chain available for equipment. SEPD have already commenced this exercise by issuing an initial "Expression of Interest" for the supply of equipment for the TASS method. This has produced an encouraging response with over ten potential suppliers expressing an interest.

iii) Operating Costs – Increased switching has the potential to have an adverse impact on asset life, therefore, appropriate mitigation measures are necessary. This could include; procurement of additional monitoring equipment; procurement of enhanced ancillary equipment i.e. additional breathers etc; and additional maintenance and inspection.