Scottish & Southern Electricity Networks

LEAN Low Energy Automated Networks

Low Energy Automated Networks (LEAN)

SDRC 9.7 Network Losses Evaluation Tool

Scottish and Southern Electricity Networks (SSEN) is the trading name of Scottish and Southern Energy Power Distribution (SSEPD), the parent company of Southern Electricity Power Distribution (SEPD), Scottish Hydro Electricity Power Distribution (SHEPD) and Scottish Hydro Electricity Transmission. SEPD is the contracted delivery body for this LCNF Project.

Document Ownership

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Version Control

Version	Date	Authors	Change Description
1.0	05/09/2019	Sarah Rigby / Maciej Fila	Final version for submission following internal review and sign-off

SDRC Report Specification

Criterion 9.7 Network Losses Evaluation Tool	• Completion of a Network Losses Reduction Tool so that DNOs can clearly assess cost benefit 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	Evidence: The tool will be presented to Ofgem in final format. A standardised SEPD work instruction / technical guide will be published.
Date	5th September 2019

Executive Summary

The Low Energy Automated Networks (LEAN) project has developed and applied Transformer Auto Stop Start (TASS) technology to reduce losses at 33/11kV primary substations.

The key principal of TASS is to switch off one of a number of transformers in a primary substation at times of low demand to avoid the fixed iron losses associated with that transformer - akin to turning off a car engine when the vehicle isn't driving anywhere.

The TASS system provides local, automated control within the substation to monitor the loading and control this switching, and to respond to SCADA alarms and status information from other network assets. In addition, commands incorporated into the Distribution Management System (DMS) provide the central network Control Room with remote supervision and management capability. The technology has been deployed in primary substations on the SEPD network since June 2018, and over the twelve month trial period has achieved energy savings of over 67 MWh in total across the two trial sites, with full operation reducing transformer losses by ~25-30%. No impacts on asset health due to TASS operation have been identified through the suite of testing and monitoring techniques applied.

This report presents the material created to support the identification of substations suitable for TASS deployment, including the cost benefit analysis tool developed to evaluate the reduction in network losses, and describes how this assessment may be integrated into Business as Usual practices, in accordance with the Project Direction and to meet the requirements of SDRC 9.7.

An overview of the LEAN project and the context of this SDRC 9.7 report is given in **Section 1**.

Section 2 describes the TASS Evaluation Tool developed to undertake cost benefit analysis and assess the financial viability of TASS deployment at specific sites, and the Substation Assessment Process which provides a framework around the use of the tool to appraise the technical feasibility of applying TASS at individual substations.

Section 3 describes the TASS Evaluation Tool and Site Assessment training provided to SEPD Asset Management colleagues who would be responsible for identifying sites suitable for TASS application, in accordance with the plan for potential integration into Business as Usual should the technology be rolled out across the business.

The next steps for the project are set out in the concluding **Section 4**.

Interested parties are very welcome to contact the LEAN project team with any enquiries via lean@sse.com.

Contents

Acronyms

ANT	Active Network Topology
BAU	Business as Usual
CB	Circuit Breaker
CBA	Cost Benefit Analysis
CoP	Crossover Point for TASS
DGA	Dissolved Gas Analysis
DMS	Distribution Management System
DNO	Distribution Network Operator
DSO	Distribution System Operator
ENA	Energy Networks Association
ER	Engineering Recommendation
EV	Electric Vehicle
GB	Great Britain
LCNF	Low Carbon Networks Fund
LCTs	Low Carbon Technologies
LEAN	Low Energy Automated Networks
PD	Partial Discharge
PoW	Point on Wave switching
PV	Photovoltaic
RIIO	Revenue = Incentives + Innovation + Outputs Ofgem's network price control framework
SCADA	Supervisory Control and Data Acquisition
SDRC	Successful Delivery Reward Criteria
SEPD	Southern Electric Power Distribution
SSEN	Scottish and Southern Electricity Networks
TASS	Transformer Auto Stop Start
ToU	Time of Use tariffs

1 Introduction

1.1 Overview of LEAN

The Low Energy Automated Networks (LEAN) project aims to establish whether it is technically feasible and economically viable to implement the proposed energy efficiency methods at 33/11kV primary substations on the Southern Electric Power Distribution (SEPD) network. It is a £3.1m project supported by Ofgem's Low Carbon Networks Fund (LCNF).

The two methods considered within LEAN are:

- Transformer Auto Stop Start (TASS) - this is the automated switching out of one of the transformers in a primary substation at times of low demand to reduce energy losses
- Alternative Network Topology (ANT) - this would make use of existing 11 kV feeder automation where available to allow a TASS site to operate in parallel with an adjacent primary substation

Prior to developing and trialling these technologies, the first phase of the project assessed the costs, benefits and risks associated with their application.

Within this, the work to validate the business case for the technologies indicated that TASS may be suitable for implementation at around 430 primary substations across the GB distribution network, providing an energy saving in the region of 1,185,000 MWh over 45 years, equating to around 467,000 tonnes of CO_2e. The cumulative discounted net benefit associated with this saving would be in the region of £18 million[1]. This work also concluded that it is not considered financially viable to deploy ANT with TASS[2].

Accordingly, the decision was taken to proceed with developing and demonstrating the TASS technology on the SEPD network[3], and the trial period has now concluded following twelve months of successful TASS operation and proven reductions in substation losses.

[1] derived using Ofgem's RIIO-ED1 CBA figure for the value of losses and the 2016 Electricity GHG conversion factor and 2016 traded carbon price

[2] as reported in LEAN SDRC 9.2 'Business Case Validation', March 2016 - available via the ENA's Smarter Networks Portal www.smarternetworks.org/project/sset207-01/documents

[3] as reported in LEAN SDRC 9.3 'Phase Two Decision Point', July 2016 - available via the ENA's Smarter Networks Portal www.smarternetworks.org/project/sset207-01/documents

1.2 Project Structure

The project has three distinct phases:

Phase One comprised the development of a comprehensive understanding of the costs, benefits and risks associated with deployment of the LEAN technologies. The information obtained during this phase supported evaluation of the business case, and a methodology for undertaking Cost Benefit Analysis on a site by site basis was created.

Phase Two focused on validation of the technology through deployment and demonstration at primary substations selected to be representative of SEPD and GB distribution network scenarios, but also ensuring that there is minimal risk of supply interruptions.

Phase Three encompasses monitoring of the transformers at the substations selected for technology deployment over the trial operational period to capture relevant learning.

A Decision Point was incorporated into the project plan to ensure that there was value in proceeding from Phase One to the trial stages. To inform this decision, the findings from Phase One and the conclusions regarding the business case for the technologies were presented to both internal and external stakeholders, including GB DNOs. The responses received through this consultation supported SEPD's decision to continue the project and develop the TASS technology for trial on the SEPD network.

1.3 Overview of SDRC 9.7

This document describes the LEAN project outputs created to support DNO assessment of the financial viability and technical feasibility of applying TASS at individual substations.

The Successful Delivery Reward Criteria (SDRC) are defined in the LEAN Project Direction. In accordance with the SDRC 9.7 evidence requirements the material delivered comprises:

- The TASS Evaluation Tool which can be used by DNOs to assess the losses achievable through deploying TASS technology and provide a cost benefit analysis on a site by site basis
- Confirmation of the TASS Evaluation Tool and Site Assessment training provided to relevant internal SEPD colleagues, supporting the plan for potential integration into 'Business as Usual' practices
- A TASS Evaluation Tool User Guide detailing the process for determining the benefits and financial viability of applying TASS at specific substations
- Complementing the TASS Evaluation Tool User Guide, a TASS Technology Substation Assessment Guide setting out the methodology used to determine the technical feasibility of installing TASS at sites which indicate a positive net benefit

To provide context for the scope of SDRC 9.7, the following companion SDRCs relate to the development and trial of the TASS technology through Phase Two and Phase Three of the project:

- SDRC 9.4 'Initial Learning from Trial Installation and Integration' - comprehensive information on the technology developed, its integration with existing network assets, the operational principles designed into the scheme, and the factors relevant to the scalability and replicability of the system for wider deployment across other network areas, together with an initial assessment of the performance of TASS

- SDRC 9.5 'Monitoring & Analysis' - an appraisal of the techniques used to monitor the transformers and other substation assets, together with an evaluation of the implications of increased switching due to TASS on both network asset health and power quality

- SDRC 9.6 'Site Performance to Date' - a detailed review of the losses savings achieved through TASS operation, and evaluation of both the benefits of the technology and costs of deployment to refine the business case

- SDRC 9.8 'Knowledge & Dissemination' - the project closedown report, including consideration of the wider deployment of the technology across the SEPD network if applicable

SDRCs 9.4, 9.5 and 9.6 have been published and are available via the ENA's Smarter Networks Portal[4], and SDRC 9.8 will be published on conclusion of the project.

[4] www.smarternetworks.org/project/sset207-01/documents

2 Site Assessment for TASS Deployment

To support the identification of substations that would be suitable for TASS deployment, a cost benefit analysis tool and substation assessment process were developed in the first phase of the LEAN project.

The cost benefit analysis tool appraises the financial viability of applying TASS at individual substations by simulating TASS operation with site specific load profiles and assigning monetary values to the derived losses saving and associated reduction in CO_2 emissions.

The stepwise assessment process then provides a framework around the use of this tool to evaluate the technical feasibility of implementing TASS at specific substations.

Following the development and trial of TASS technology on the SEPD network, the initial tool has been refined to incorporate additional functionality which reflects the operational design of the scheme, and the assessment process has been updated in light of experience gained through the deployment of TASS.

The two sections below describe the design and use of the TASS Evaluation Tool and principles of the Substation Assessment Process.

The Excel tool and accompanying VBA code documentation, together with the TASS Evaluation Tool User Guide and TASS Technology Substation Assessment Guide, are available to other DNOs as Appendices A, B, C and D of this report respectively, and can be requested by emailing the LEAN project team via lean@sse.com. DNOs are also invited to request an introductory session from the team on how to use the tool to assess primary substations on their own networks.

TASS Evaluation Tool

The TASS Evaluation Tool uses site specific transformer and load profile data to simulate TASS operation and determine the losses saved over the course of a year by switching a transformer out at times of low demand. These results are then used to calculate the cumulative discounted net financial benefit of applying TASS at each substation based on the energy and carbon saved by reducing losses, consistent with the RIIO CBA approach defined by Ofgem.

To provide further insight, it is also possible to use the model to undertake sensitivity analysis and compare results for:

- different cost assumptions
- potential changes to demand profiles
- the application of an alternative Crossover Point (the load level for TASS switching)

The evaluation tool has been produced as an Excel spreadsheet which simulates TASS operation at one or more sites through macros programmed in Visual Basic for Applications (VBA), thereby avoiding the need for any specialist, proprietary software or systems to run the model. Building on the initial version created during Phase One of the project, consultancy Mott MacDonald have further developed the tool to meet the enhanced requirements specified by the LEAN project team.

Functionality

The modelling functionality incorporated into the tool emulates the operational TASS scheme designed and trialled through the LEAN project, as described below.

Load Based and Time Based Switching

- The tool can simulate the operation of TASS as applied to one transformer or to multiple transformers within a substation - i.e. with TASS switching one transformer only or alternating operation between two or more transformers each time a transformer is switched out.

  ➡ This reflects the adaptability of the system design to different substation configurations and operational requirements.
- Load based switching reflects the TASS algorithm's response to changes in substation loading, with one transformer being switched out at times of low demand to reduce losses, and then switched back in once the load increases above the defined Crossover Point.

  ➡ This is the key principle of using TASS to deliver energy savings by reducing transformer losses.
- Time based switching can be incorporated into the assessment to replicate the fact that TASS has the functionality for scheduled switching events, such that when no load based switching has occurred over a given period, TASS will initiate:
  - a change-over of TASS operation between transformers (on a site with more than one TASS transformer)
  - test switching (in/out of service) of the transformer (on a site with only one TASS transformer)

  with this switching occurring on the scheduled day/time.

  ➡ This operational functionality provides reassurance that TASS switching (and the transformer(s)) continue to operate as designed.

Crossover Point

- The Crossover Point (CoP) for TASS switching is implemented with high and low bands around the defined CoP, and the algorithm will only initiate switching if the load has been above the higher band or below the lower band for a specified period of time.

  ➡ This fulfils the objective of TASS but avoids rapid switching of transformers in and out of service when the load fluctuates around the crossover level.
- The tool will derive the optimal CoP for each substation, defined as the point where the losses with a TASS transformer out of service equal those with all transformers in service, however an alternative value for the CoP can also be defined by the User.

  ➡ This allows a comparison of the results in the event that there is an operational reason for applying a specific CoP at a given site.

Load Modelling

- In addition to inputting actual measured load data for each site, the tool allows up to three 'overlay' load profiles to be entered which adjust the actual load data readings for each site to provide sensitivity analysis around the CBA based on historic load data.

  ➡ These overlay profiles can be used to explore how the benefits of TASS may be affected with potential future changes to demand. For example, they may be used to represent such things as:

  - overall increasing or decreasing demand - e.g. changes in conventional demand due to new connections or higher energy efficiency standards
  - uptake of Low Carbon Technologies (LCTs) - e.g. increasing numbers of photovoltaic (PV) installations which reduce daytime substation loading, or electric vehicle (EV) charging which increases demand over the evening peak
  - impacts of smart meters and time of use (ToU) tariffs - e.g. where these may act to smooth demand over the course of a day

Financial Modelling

- In addition to fixed Capex costs and annual Opex costs, variable Opex costs can be applied as a cost per e.g. 100 switching operations.

  ➡ This can be used to reflect any situation where the number of switching operations seen may change the associated costs, e.g. where information on the number of switching operations is factored into the data assessed for targeting maintenance activities on assets such as transformers and circuit breakers.

- The tool can provide CBA results for up to three cost scenarios.

  ➡ This allows the sensitivity around the cost assumptions to be explored.

- The tool allows the user to specify a second CBA assessment period such that the tool presents the results for:

  - the remaining life of transformers, and
  - any other user defined time period (e.g. to align to price control timeframes)

  ➡ These options are provided to ensure that DNOs can align the assessment to their investment decision timeframes.

Inputs

The key inputs to the TASS Evaluation Tool comprise:

- settings for the analysis and simulation of TASS operation
- transformer data for each transformer at the site(s) under assessment
- load data covering one full year of operation for each site
- financial data associated with applying TASS (inc. capital costs, operational costs, capitalisation rate, values for losses and carbon)

Figure 1, Figure 2 and Figure 3 give screenshots showing populated examples of the associated Calculation Setup ('CalcSetup'), Site & Transformer Data ('SiteTxSetup') and Load Profile Data ('LoadData') input sheets respectively.

Figure 1 - Calculation Setup input sheet

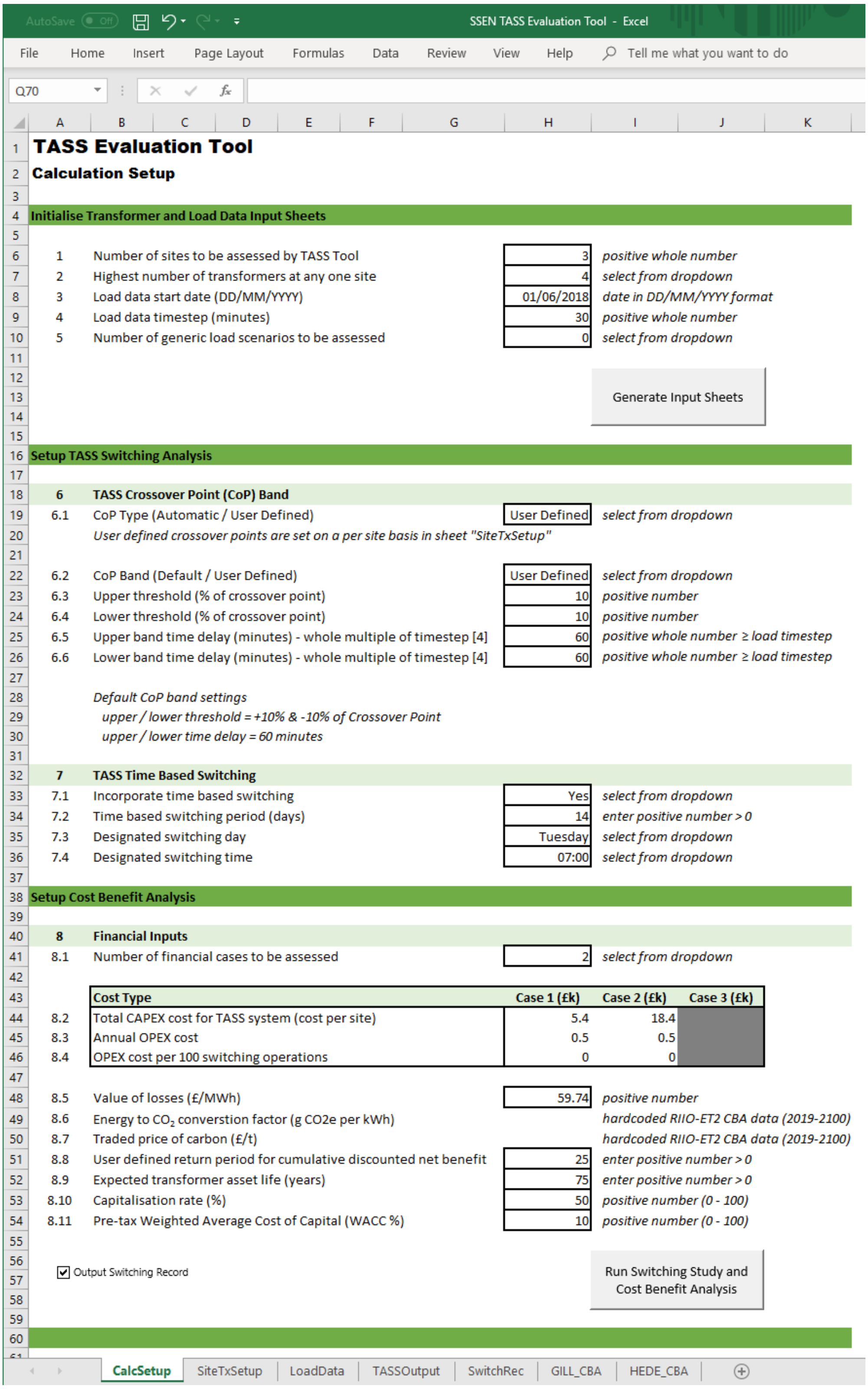
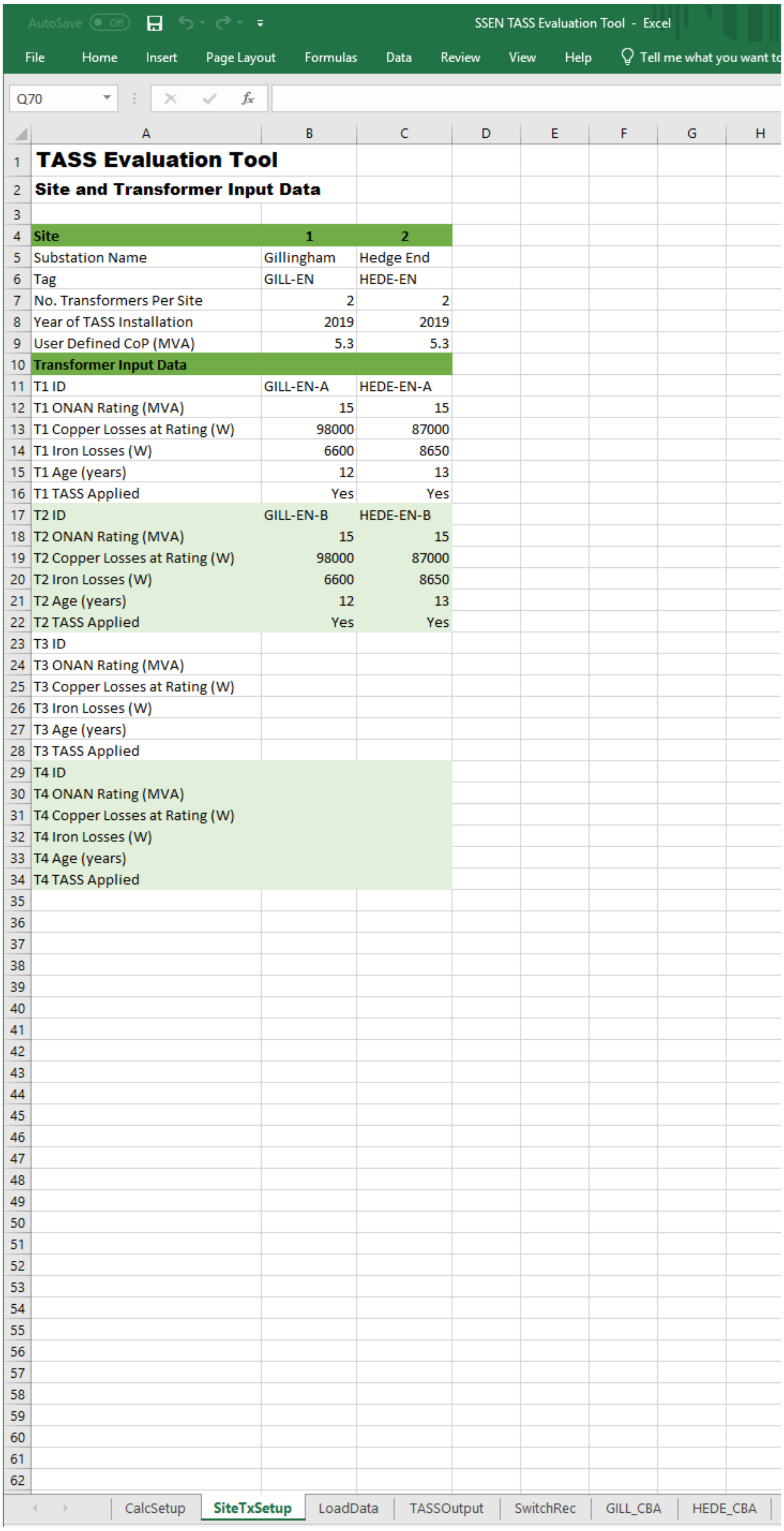


Figure 2 - Site & Transformer Data input sheet



1	**TASS Evaluation Tool**		
2	**Site and Transformer Input Data**		
3			
4	**Site**	**1**	**2**
5	Substation Name	Gillingham	Hedge End
6	Tag	GILL-EN	HEDE-EN
7	No. Transformers Per Site	2	2
8	Year of TASS Installation	2019	2019
9	User Defined CoP (MVA)	5.3	5.3
10	**Transformer Input Data**		
11	T1 ID	GILL-EN-A	HEDE-EN-A
12	T1 ONAN Rating (MVA)	15	15
13	T1 Copper Losses at Rating (W)	98000	87000
14	T1 Iron Losses (W)	6600	8650
15	T1 Age (years)	12	13
16	T1 TASS Applied	Yes	Yes
17	T2 ID	GILL-EN-B	HEDE-EN-B
18	T2 ONAN Rating (MVA)	15	15
19	T2 Copper Losses at Rating (W)	98000	87000
20	T2 Iron Losses (W)	6600	8650
21	T2 Age (years)	12	13
22	T2 TASS Applied	Yes	Yes
23	T3 ID		
24	T3 ONAN Rating (MVA)		
25	T3 Copper Losses at Rating (W)		
26	T3 Iron Losses (W)		
27	T3 Age (years)		
28	T3 TASS Applied		
29	T4 ID		
30	T4 ONAN Rating (MVA)		
31	T4 Copper Losses at Rating (W)		
32	T4 Iron Losses (W)		
33	T4 Age (years)		
34	T4 TASS Applied		

Figure 3 - Load Profile Data input sheet - the overlay load profile represents a 4% increase in demand over night

SSEN TASS Evaluation Tool - Excel

	A	B	C	D
1	**TASS Evaluation Tool**			
2	**Load Data & Overlay Load Profiles**			
3				
4	**Site**	**Overlay Load**	**1**	**2**
5	Substation / Load Name	#1	Gillingham	Hedge End
6	Units	%	MVA	MVA
7				
8	**Time (No. Time Steps - 17520)**			
9	01/06/2018 (00:00)	4	2.621091604	2.853227615
10		4	2.523926497	2.694715023
11		4	2.42676115	2.694715023
12		4	2.329596043	2.499622345
13		4	2.232430696	2.499622345
14		4	2.135265589	2.341109753
15		4	2.038100481	2.341109753
16		4	1.940935254	2.341109753
17		4	1.956578374	2.341109753
18		4	2.037844658	2.341109753
19		4	2.119110823	2.341109753
20		4	2.200376987	2.341109753
21		4	2.281643391	2.341109753
22		4	2.362909555	2.341109753
23		4	2.44417572	2.341109753
24		0	2.525442123	2.341109753
25		0	2.606708288	2.341109753
26		0	2.687974453	3.133672953
27		0	2.72824645	4.279841423
28		0	Shutdown	Shutdown
29		0	2.780526876	4.560286522
30		0	2.848767996	4.377387524
31		0	2.917009115	4.377387524
32		0	2.985250235	4.353406906
33		0	3.053491592	4.353000641
34		0	3.121732712	4.377387524
35		0	3.189973831	4.377387524
36		0	3.258215189	4.377387524
37		0	3.326456308	4.377387524
38		0	3.394697428	4.279841423
39		0	3.462938547	4.279841423
40		0	3.531179905	4.279841423
41		0	3.599421024	4.109135151
42		0	3.667662144	4.340807438
43		2	3.735903263	4.7553792
44		2	3.804144621	4.779766083
45		2	3.719545841	4.779766083
46		4	3.61952281	4.633446217
47		4	3.519499779	4.633446217
48		4	3.419476748	4.64563942
49		4	3.319453716	4.64563942
50		4	3.219430685	4.474933624
51		4	3.119407892	4.474933624
52		4	3.019384861	3.926236153
53		4	2.91936183	3.926236153
54		4	2.819338799	3.633597374
55		4	2.719315767	3.633597374
56		4	2.619292736	3.047710419
57	02/06/2018 (00:00)	4	2.519269705	3.036126614
58		4	2.419246674	2.609361887
59		4	2.319223881	2.609361887
60		4	2.21920085	2.3776896
61		4	2.210031986	2.3776896
62		4	2.210031986	2.267950058

CalcSetup | SiteTxSetup | LoadData | TASSOutput | SwitchRec | GILL_CBA | HEDE_CBA

Outputs

The tool then provides the following outputs for each substation and load profile scenario assessed:

- the results of the switching study for each annual load profile assessed
- the associated CBA figures
- monthly figures and charts for the losses savings and transformer switching activity

Figure 4 and Figure 5 give screenshots showing populated examples of the associated Switching Study ('TASSOutput') and site CBA ('**site*_CBA)') output sheets respectively.

Figure 4 - Switching Study output sheet giving results for each site, load profile scenario and CoP assessed

	A	B	C	D	E
1	**TASS Evaluation Tool**				
2	**Switching Behaviour of TASS System**				
3					
4	**Site Name**	Gillingham	Gillingham	Hedge End	Hedge End
5	**Load Scenario**	Existing	#1	Existing	#1
6	Site Tag	GILL-EN	GILL-EN	HEDE-EN	HEDE-EN
7	Site Capacity (MVA)	30	30	30	30
8	Site Firm Capacity (MVA)	15	15	15	15
9	Number of Transformers on Site	2	2	2	2
10	Number of TASS Transformers	2	2	2	2
11	Total Site Copper Loss (kW)	196.00	196.00	174.00	174.00
12	Total Site Iron Loss (kW)	13.20	13.20	17.30	17.30
13	Number of Load Steps	17520	17520	17520	17520
14	Number of Load Data Errors	15	0	16	0
15	Number of Time Steps with Zero Load Value	0	0	0	0
16	Number of Reverse Power Flow Time Steps	0	0	0	0
17	**AUTOMATIC CoP RESULTS**				
18	Site Energy Saving (MWh)	38.01	37.25	45.34	44.07
19	Automatic CoP (MVA)	5.51	5.51	6.69	6.69
20	No. Load Based Switching Events	0	0	2	9
21	No. Time Based Switching Events - Test Switching	0	0	0	0
22	No. Time Based Switching Events - Tx Changeover	25	25	23	22
23	T1 ID	GILL-EN-A	GILL-EN-A	HEDE-EN-A	HEDE-EN-A
24	T1 Specific CoP	5.51	5.51	6.69	6.69
25	T1 Number Switches ON	13	13	13	16
26	T1 Number Switches OFF	13	13	13	16
27	T1 Time Steps OFF	8940	8940	8838	7558
28	T2 ID	GILL-EN-B	GILL-EN-B	HEDE-EN-B	HEDE-EN-B
29	T2 Specific CoP	5.51	5.51	6.69	6.69
30	T2 Number Switches ON	12	12	12	15
31	T2 Number Switches OFF	13	13	13	16
32	T2 Time Steps OFF	8577	8577	8663	9894
33	T3 ID				
34	T3 Specific CoP				
35	T3 Number Switches ON				
36	T3 Number Switches OFF				
37	T3 Time Steps OFF				
38	T4 ID				
39	T4 Specific CoP				
40	T4 Number Switches ON				
41	T4 Number Switches OFF				
42	T4 Time Steps OFF				
43	Monthly Switching Events and Energy Savings				
44	Jan (no. switching operations)	6	6	6	12
45	Feb (no. switching operations)	4	4	4	2
46	Mar (no. switching operations)	4	4	4	4
47	Apr (no. switching operations)	4	4	4	6
48	May (no. switching operations)	4	4	4	4
49	Jun (no. switching operations)	3	3	3	3
50	Jul (no. switching operations)	6	6	6	6
51	Aug (no. switching operations)	4	4	4	4
52	Sep (no. switching operations)	4	4	4	4
53	Oct (no. switching operations)	4	4	4	4
54	Nov (no. switching operations)	4	4	4	6
55	Dec (no. switching operations)	4	4	4	8
56	Jan (MWh)	2.46	2.36	2.95	2.79
57	Feb (MWh)	2.61	2.53	3.01	2.89
58	Mar (MWh)	3.19	3.12	3.85	3.74
59	Apr (MWh)	3.39	3.34	4.03	3.94
60	May (MWh)	3.65	3.61	4.37	4.29

Figure 5 - CBA output sheet for one site giving results for each load profile scenario and CoP assessed

TASS Evaluation Tool

Hedge End (HEDE-EN) CBA Results Sheet

TASS Switching Analysis			
SiteTag	HEDE-EN	Capacity (MVA)	30
No. Transformers	2	Firm Capacity(MVA)	15
No. TASS Transformers	2	TASS Installation Date	2019
Age of Oldest TASS Tx. in 2020 [Remaining Life]	13 [62]	Start / End of CBA Study [User Defined Return Period]	2019 / 2081 [2019 - 2044]

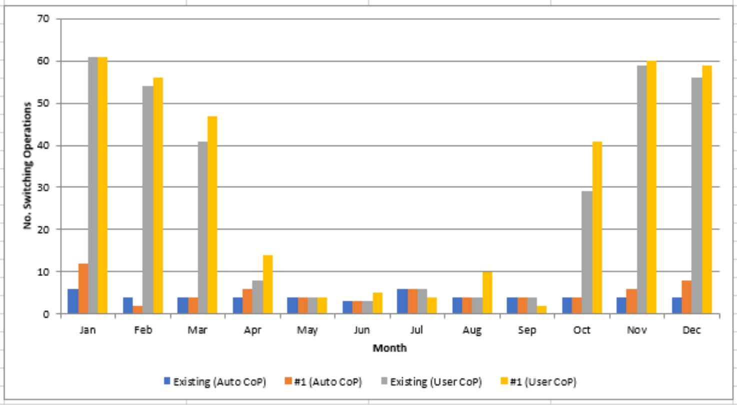
TASS Switching per Annum: Automatic CoP (6.69 MVA)			No. Switching Events due to
Load Scenario	Energy Saving (MWh)	No. Switching Operations	Load / Test / Changeover*
Existing	45.34	51	2 / 0 / 23
#1	44.07	63	9 / 0 / 22
*one event in this column is equal to a full round of Tx switching (load based = off/on, time based = on/off)			

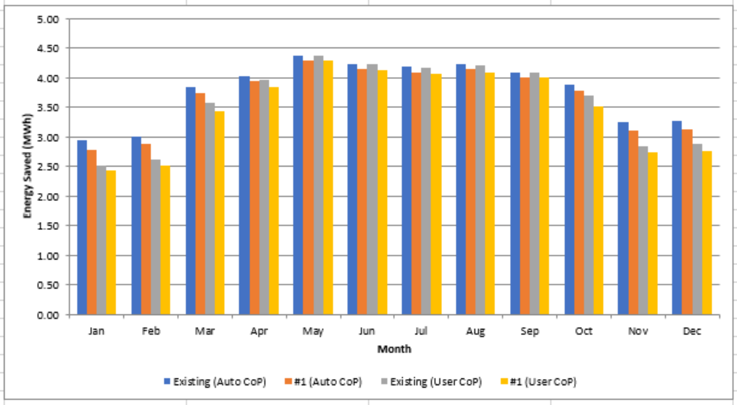
TASS Switching per Annum: User Defined CoP (5.3 MVA)			No. Switching Events due to
Load Scenario	Energy Saving (MWh)	No. Switching Operations	Load / Test / Changeover
Existing	43.20	329	154 / 0 / 10
#1	41.83	363	174 / 0 / 7

Cost Benefit Analysis: Automatic CoP Cumulative discounted net benefits at end of transformer life [after 25 years]			
Load Scenario	Case 1 (£k)	Case 2 (£k)	Case 3 (£k)
Existing	54.8 [38]	34.6 [21.1]	
#1	52.4 [36.5]	32.3 [19.6]	

Cost Benefit Analysis: User Defined CoP Cumulative discounted net benefits at end of transformer life [after 25 years]			
Load Scenario	Case 1 (£k)	Case 2 (£k)	Case 3 (£k)
Existing	50.8 [35.4]	30.7 [18.6]	
#1	48.3 [33.8]	28.2 [17]	

Total forecast CO_2 savings to end of transformer life [after 25 years]		
Load Scenario	Automatic CoP (tCO_2)	User Defined CoP (tCO_2)
Existing	267.3 [239.3]	254.7 [228]
#1	259.9 [232.6]	246.6 [220.8]





CalcSetup | SiteTxSetup | LoadData | TASSOutput | SwitchRec | GILL_CBA | HEDE_CBA

RIIO Figures for the Value of Losses & Carbon

To derive the financial benefit of applying TASS, figures related to the value of losses and associated carbon savings are taken from Ofgem's RIIO-ET2 Draft CBA Template v1.0[5] as follows:

- value of losses [£/MWh] - a fixed value
- greenhouse gas conversion factor [CO_2e/kWh] - a projection to 2100 reflecting the decarbonisation of electricity with a linear reduction from 2017/18 to 10g/kWh in 2050 - original source: DEFRA
- traded carbon price [£/t, 2018/19 prices] - a projection to 2100 reflecting an increasing value of carbon - original source: BEIS traded carbon price (central)

The RIIO-ET2 Draft CBA figures are used at present as these are more recent than the RIIO-ED1 figures, and the forthcoming RIIO-ED2 figures are anticipated to be similar if not the same. Should the published RIIO figures change, however, it is possible to apply new values within the TASS Evaluation Tool through password access to the relevant worksheet.

It is also noted that the calculation formulas in the RIIO-ET2 Draft CBA Template v1.0 apply the 2020 traded carbon price figure to all calculation years, rather than applying the forecast figure for the year in question to the associated calculation year. Further, whilst there is an input value for losses on the 'Fixed Data' sheet in the template, this is not carried through to any of the calculation formula. It is understood that these points have been identified and are being addressed through Ofgem's RIIO-ET2 consultation and engagement process with the Transmission Operators, accordingly the TASS Evaluation Tool assesses the value of both losses and carbon, and applies the projected forecast figures to each associated year for the CBA calculation.

Validation of the TASS Evaluation Tool

In addition to detailed testing of the spreadsheet and VBA code, to validate the model the results of the monthly losses savings calculated for Gillingham and Hedge End using June 2018 to May 2019 load profile data have been compared with the losses saved at site during this trial period.

[5] available from the Ofgem website
www.ofgem.gov.uk/publications-and-updates/riio-2-draft-data-templates-and-associated-instructions-and-guidance

Table 1 presents the associated figures together with comments regarding the operation of TASS each month.

It can be seen that the modelled figures correspond well to the reductions achieved through full TASS operation over the course of a month at each site. The minimal differences here relate to the fact that the load data used within the model is point in time data for given time steps (in this case 30 mins), whereas the installed TASS system will respond in real time to changes in substation loading. Whilst the results therefore represent a minor approximation of the performance of TASS at a given site, the tool provides a robust evaluation of the benefits and financial viability of applying TASS.

For each month in which operation was restricted, the difference in the figures correlates with the proportion of the month during which the system was operational. These months reflect periods of time during which TASS was suspended whilst the project team investigated the operational situations described in SDRC 9.6 'Site Performance to Date'[6]. In each case the cause of the issue was established and it was confirmed that the TASS system had operated as designed to provide an appropriate response, with none of the issues experienced representing adverse implications for the application of TASS. Consequently these events provided indispensable live testing of the system, demonstrating that TASS was able to quickly identify a problem, halt operation if needed and raise a relevant alarm in the DMS to notify the Control Engineers and project team.

[6] available via the ENA's Smarter Networks Portal www.smarternetworks.org/project/sset207-01/documents

Table 1 - Comparison of modelled and actual monthly losses savings

Gillingham				
	TASS Evaluation Tool Assessment MWh	losses saved during the trial MWh	comparison	comments regarding trial operation
June	3.53	1.01	29%	TASS operation commenced 22 June 2018
July	3.70	3.52	95%	*full TASS operation*
August	3.63	3.61	100%	*full TASS operation*
September	3.33	3.40	102%	*full TASS operation*
October	3.05	3.09	101%	*full TASS operation*
November	2.58	2.67	104%	*full TASS operation*
December	2.90	1.70	59%	TASS operational for ~15 days in December
January	2.46	2.53	103%	*full TASS operation*
February	2.61	2.67	103%	*full TASS operation*
March	3.19	3.20	100%	*full TASS operation*
April	3.39	1.67	49%	TASS operational for ~15 days in April
May	3.65	3.27	89%	TASS operational for ~28 days in May
Hedge End				
	TASS Evaluation Tool Assessment MWh	losses saved during the trial MWh	comparison	comments regarding trial operation
June	4.23	3.18	75%	TASS operation commenced 8 June 2018
July	4.16	3.01	72%	TASS operational for ~25 days in July
August	4.22	3.66	87%	TASS operational for ~27 days in August
September	4.09	4.07	99%	*full TASS operation*
October	3.69	2.22	60%	TASS operational for ~21 days in October
November	2.85	2.22	78%	TASS operational for ~24 days in November
December	2.88	0.36	12%	TASS operational for ~4 days in December
January	2.52	0.11	4%	TASS operational for ~2 days in January
February	2.63	2.66	101%	*full TASS operation*
March	3.58	3.55	99%	*full TASS operation*
April	3.97	3.93	99%	*full TASS operation*
May	4.37	4.29	98%	*full TASS operation*

User Guide for the TASS Evaluation Tool

The TASS Evaluation Tool User Guide[7] details instructions for using the tool to generate site specific CBA results and assess the financial viability of applying TASS. This provides a reference document for those responsible for identifying where to deploy TASS, and will support the plan for potential integration into Business as Usual (BAU) practices should the technology be rolled out across the business.

VBA Code Documentation

The Code Base and Commentary[8] document presents the VBA code written to deliver the required functionality of the TASS Evaluation Tool, together with flowcharts for the operation of each module of the program.

Substation Assessment Process

The Substation Assessment Process establishes a stepwise approach for identifying sites that may be suitable for TASS based on both the financial viability and technical feasibility of deployment.

The assessment comprises five key steps:

- Step One - TASS Evaluation Tool cost benefit analysis - generic cost assumptions
- Step Two - is there a dedicated 33 kV circuit breaker?
- Step Three - review of asset condition
- Step Four - detailed protection and control study
- Step Five - TASS Evaluation Tool cost benefit analysis - with site specific costs

and more detail on each of these is provided on the following page.

Once approval and sign off has been received by the appropriate senior managers, each site can then be assigned for installation with the relevant documentation from the protection and control study issued to the TASS delivery team.

[7] TASS Evaluation Tool User Guide, Mott MacDonald, August 2019

[8] Code Base and Commentary, Mott MacDonald, August 2019

1 CBA - generic cost assumptions

The first stage is to assess the financial viability of applying TASS at each site of interest using the TASS Evaluation Tool to provide a cost benefit analysis (CBA) based on generic cost assumptions.

This initial CBA assessment can be used to draw up a shortlist of potential substations at which TASS may be financially viable, with these meriting further assessment to determine the technical feasibility of applying TASS at each site.

2 is there a dedicated 33 kV circuit breaker?

A key requirement for the application of TASS is the ability to switch out and de-energise individual transformers independently, consequently a dedicated circuit breaker on the HV 33 kV side is required for each transformer.

The second step therefore comprises a review of each shortlisted site to determine whether or not the associated transformers have dedicated 33 kV circuit breakers.

3 review of asset condition

The third step is to assess the health of the transformers and switchgear at each site, inc:

- a review of all available condition monitoring information, such as asset inspection reports and the results of oil samples & dissolved gas analysis from the transformers, together with information from Field Teams regarding any known issues
- visual inspections of the substation assets - it is recommended that these inspections be included as part of a site survey for TASS deployment undertaken by suitably competent and authorised staff

Oil samples, partial discharge (PD) surveys and/or transformer condition assessment tests may also be considered of value to further validate that there are no pre-existing issues with the assets, and to provide a set of reference/bench mark data for any future tests following the application of TASS.

4 detailed protection and control study

For each site that meets the requirements of steps one to three, a detailed study of the substation protection scheme and the comms systems and SCADA configurations at the site is to be undertaken.

This should be informed by the findings from the TASS site survey, as well as information taken from central data systems and records. The study should also evaluate whether or not controlled Point on Wave switching is required to minimise inrush currents or comply with ER P28 (Issue 2) voltage fluctuation limits when energising the transformers.

The purpose of this study is to:

- identify any issues which may prevent the TASS system from working correctly
- document the factors relevant to integrating TASS with the existing protection and comms systems at the site
- identify all equipment required to implement TASS at the site
- derive site specific Capex & Opex figures for the specified equipment and the resources and time required for installation & commissioning

5 CBA - site specific costs

Where no issues are identified through the protection and control study, the final stage is to enter the site specific costs into the TASS Evaluation Tool and re-run the CBA to confirm the financial benefit of applying TASS, including any relevant sensitivity analysis around the historic load data or Crossover Point.

All sites which demonstrate a positive benefit through this assessment may be taken forward for TASS implementation.

Technical Guide for the Substation Assessment Process

The TASS Technology Substation Assessment Guide[9] provides detailed guidance on the stepwise methodology used to identify sites suitable for the application of TASS. Alongside the TASS Evaluation Tool User Guide, this document has been developed for use by those responsible for identifying sites suitable for TASS application, and will support the plan for potential integration into BAU practices should the technology be rolled out across the business.

[9] TASS Technology Substation Assessment Guide, SSEN, August 2019

3 Training for SEPD Asset Management Engineers

TASS technology is specifically targeted at substations and automatically controls transformer switching to reduce losses. Accordingly, should the technology be rolled out to Business as Usual (BAU), the responsibility for identifying sites suitable for TASS application would primarily sit with the SEPD Substation Design team.

In preparation for potential roll out to BAU, training on the use of the TASS Evaluation Tool has therefore been provided to members of the Substation Design team, as nominated by the Substation Design Manager.

In addition, the SEPD System Planning & Investment Engineers responsible for transformers within the Portfolio Management team were invited to join the training, to build on their awareness of the technology and provide insight into the assessment process.

Both the Substation Design and Portfolio Management teams sit within SEPD's Asset Management department, which has responsibility for engineering design and asset strategy & performance.

The TASS Evaluation Tool and Site Assessment training session was held on 3 September 2019 at SSEN's Forbury Place offices in Reading, and a copy of the calendar invitation is provided as Appendix E.

The session was structured to provide:

- a brief overview of TASS and update on how the system has performed during the trials
- an understanding of the principles for identifying sites suitable for TASS
- an introduction to the TASS Evaluation Tool used to provide site specific Cost Benefit Analysis for the application of TASS
- a demonstration of how to use the tool to assess the financial viability of TASS at primary substations

The review of TASS and the stepwise site appraisal process were presented by the LEAN project team, and the associated slide pack is included as Appendix F. The functionality and use of the TASS Evaluation Tool were demonstrated by a consultant from Mott MacDonald involved in developing the tool in line with the requirements specified by the project team.

As well as providing training on the site assessment process and use of the TASS Evaluation Tool, the session provided the opportunity for questions and answers on broader aspects of the application and operation of TASS that were of interest to attendees.

Copies of both the TASS Evaluation Tool User Guide and TASS Technology Substation Assessment Guide were also issued for future reference and referral.

4 Conclusion & Next Steps

This report provides evidence that SEPD has met the requirements of SDRC 9.7, as set out in the LEAN Project Direction. In line with those requirements, the material delivered comprises:

- The TASS Evaluation Tool which can be used by DNOs to assess the losses achievable through deploying TASS technology and provide a cost benefit analysis on a site by site basis
- Confirmation of the TASS Evaluation Tool and Site Assessment training provided to relevant internal SEPD colleagues, supporting the plan for potential integration into 'Business as Usual' practices
- A TASS Evaluation Tool User Guide detailing the process for determining the benefits and financial viability of applying TASS at specific substations
- Complementing the TASS Evaluation Tool User Guide, a TASS Technology Substation Assessment Guide setting out the methodology used to determine the technical feasibility of installing TASS at sites which indicate a positive cost benefit analysis

All project outputs are available to other DNOs and can be requested by emailing the project team via lean@sse.com. DNOs are also invited to request an introductory session from the team on how to use the TASS Evaluation Tool to assess primary substations on their own networks.

Next Steps

As the formal trial period has now concluded, activities will focus on a detailed review of the potential feasibility of, or barriers to, the application of TASS technology across the network. SDRC 9.8 'Knowledge & Dissemination' forms the project closedown report, and accordingly this will address SEPD proposals for roll out of the technology if applicable, as well as providing signposts to the information and materials available as outputs from the project.

Knowledge Sharing

Interested parties are very welcome to contact the LEAN project team with any enquiries via lean@sse.com.

The following companion SDRCs relate to the development and trial of the TASS technology through Phase Two and Phase Three of the project:

- SDRC 9.4 'Initial Learning from Trial Installation and Integration' - comprehensive information on the technology developed, its integration with existing network assets, the operational principles designed into the scheme, and the factors relevant to the scalability and replicability of the system for wider deployment across other network areas, together with an initial assessment of the performance of TASS

- SDRC 9.5 'Monitoring & Analysis' - an appraisal of the techniques used to monitor the transformers and other substation assets, and to evaluate both the performance of TASS and any potential asset health or power quality implications associated with its application
- SDRC 9.6 'Site Performance to Date' - a detailed review of the losses savings achieved through TASS operation, and evaluation of both the benefits of the technology and costs of deployment to refine the business case
- SDRC 9.8 'Knowledge & Dissemination' - the project closedown report, including consideration of the wider deployment of the technology across the SEPD network if applicable

SDRCs 9.4, 9.5 and 9.6 have been published and are available via the ENA's Smarter Networks Portal[10], and SDRC 9.8 will be published on conclusion of the project.

Targeted engagement and dissemination activities will continue with both internal and external stakeholders to share information and experience. The material available to other DNOs is designed to support their appraisal of TASS and adoption of the technology on their own networks. In addition, the experience gained through the project can be evaluated by product vendors or third party service providers to inform their development of technologies or functionalities relevant to enhanced levels of decentralised control, automation and monitoring as the industry transitions to the world of DSO with increasingly dynamic operation of GB electricity networks.

[10] www.smarternetworks.org/project/sset207-01/documents

Appendices

Appendix A TASS Evaluation Tool

Appendix B Code Base and Commentary - Mott MacDonald, report ref. 410969_TASS_003_A, August 2019

Appendix C TASS Evaluation Tool User Guide - Mott MacDonald, report ref. 410969_TASS_001_A, August 2019

Appendix D TASS Technology Substation Assessment Guide - SSEN, document ref. TG-NET-TAS-001, August 2019

Appendix E Calendar invitation for the TASS Evaluation Tool and Site Assessment training session

Appendix F Slides for the TASS Evaluation Tool and Site Assessment training session

Enquiries regarding these appendices, this SDRC 9.7 report or the LEAN project in general are very welcome via lean@sse.com.