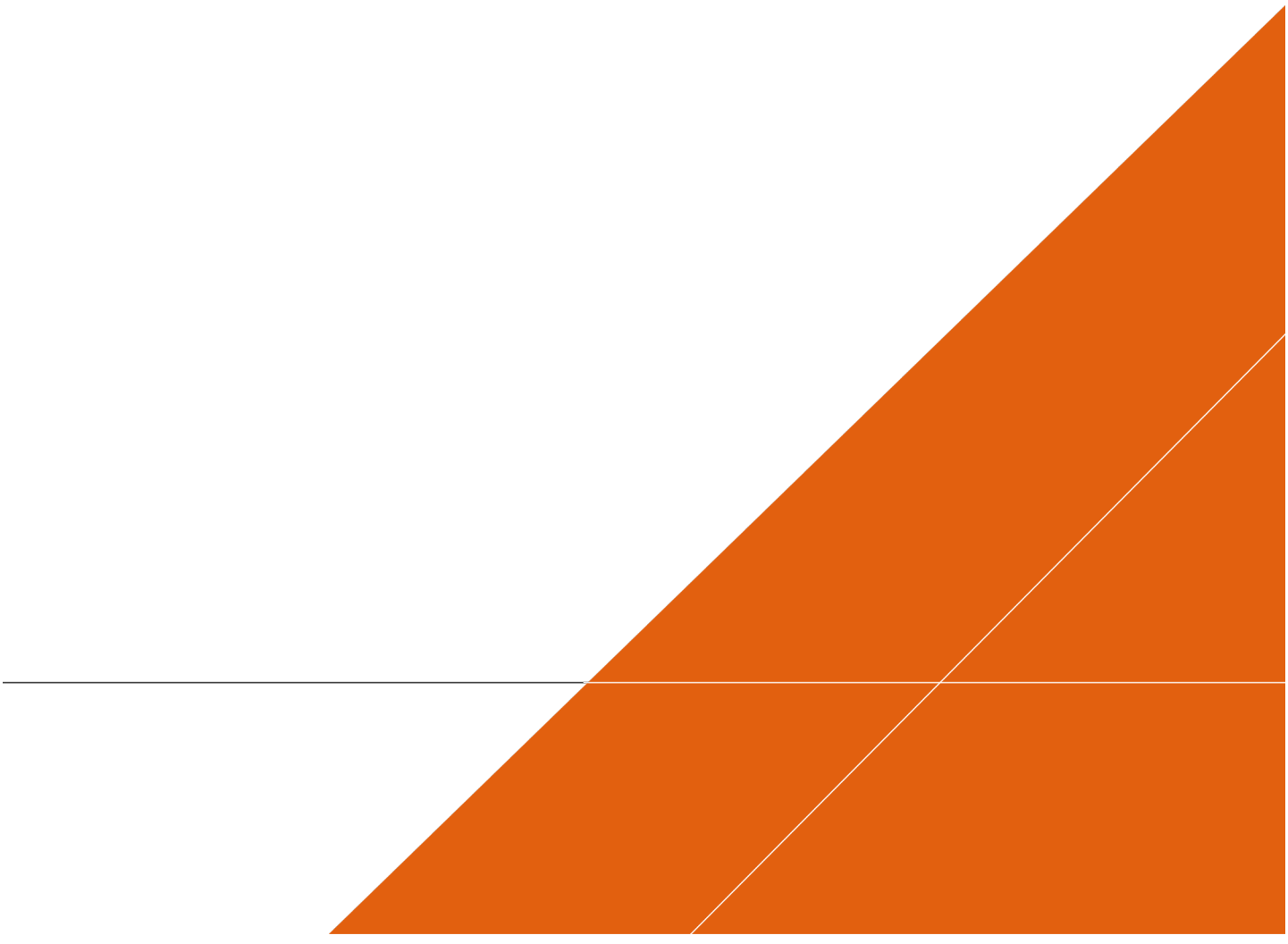
ARCADIS Design & Consultancy for natural and built assets

REDHOUSE LIVE TRIAL

BESS Fault Level Assessment

10048782/R/PW/01

JUNE 2021



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VERSION CONTROL

Version	Date	Author	Changes
A	14/6/21	P. Watson	For Comment
B	30/6/21	P. Watson	Updated with the Redhouse model in DIgSILENT 2021 SP3

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APPENDICES

APPENDIX A

Fault Levels

Executive Summary

The BESS fault level assessment study looking at scenarios associated with performing a black start from distributed energy resources (DER), specifically from Redhouse Battery Energy Storage System (BESS), are detailed in this report.

Conclusions

This report documents the fault level assessment of the BESS system in order for the protection systems on the BESS system to be evaluated for the black start condition fed via Redhouse Battery Energy Storage Scheme due to the reduction in fault levels.

1 Introduction

SP Transmission requested[1] Arcadis Consulting (UK) Ltd ("Arcadis") to provide a quotation for studies to identify the protection limitations and changes required for the proposed Redhouse Live Trial.

This will include 'local' testing on the Redhouse Battery Energy Storage System (BESS) network, and energising a section of the Redhouse GSP distribution network, and the associated transmission network, when supplied from the Redhouse BESS in both grid following (along with a diesel generator) and grid forming mode.

The scope of work required is defined within the tender document[2] in terms of technical outputs. A DIgSILENT PowerFactory model of the relevant distribution networks (modelled to the primary substation 11 kV busbars); along with the associated transmission networks was provided by SPEN. In addition, a data sheet with fault infeed data of the Redhouse BESS was provided. This was also provided within the PowerFactory model.

The purpose of this report is to document the Redhouse BESS site fault level assessment.

[1] Email from N. Miller (SPT) to P.Watson (Arcadis), 'D ReStart – Redhouse RFP',16/03/2021

[2] Request for Proposal for Consultancy Services Distributed ReStart REP REDH01 Rev 1 Dated 15/03/2021

2 Scope of Work

The scope of work required is defined within the tender document[2] in terms of technical outputs. SPEN can provide a DIgSILENT PowerFactory model of the relevant distribution networks (modelled to the primary substation 11 kV busbars); along with the associated transmission networks.

For all the combinations of generation (diesel gen on/off, BESS in grid following/forming mode and Redhouse GT1 earthing transformer in/out of service), calculate the 3 phase, phase to phase and phase to earth fault levels within the Redhouse BESS site such that Raelec (BESS site protection consultants) can assess the operation of their existing protection on the site 33 kV switchgear.

Arcadis will:

- Carry out fault level studies on the model provided to ascertain fault levels for the eight system scenarios determined.
- Provide information of fault levels at busbars and fault flows to determine contributions to faults.
  N.B. The Redhouse BESS site will be earthed at 33 kV using a temporary earthing transformer. A data sheet for an earthing transformer which may be hired will be provided.

3 Redhouse Network

3.1 Fault Level Calculation

Using the network model provided fault levels and fault flows were determined for the eight scenarios required.

The parameters for the BESS transformer were updated in the DIgSILENT model [1] based on the provided datasheet [2]. The impedance for the BESS transformer was modelled as 8.5% (5% - 8.5% provided in the datasheet) to give smallest fault levels (worse case fault current for protection setting).

The diesel generator was modelled assuming that it provides a maximum fault current of 3 x rated current. The diesel generator in the provided model was modelled as 3 parallel 1.25 kVA rated machines.

The network model is detailed in Figure 3.1.

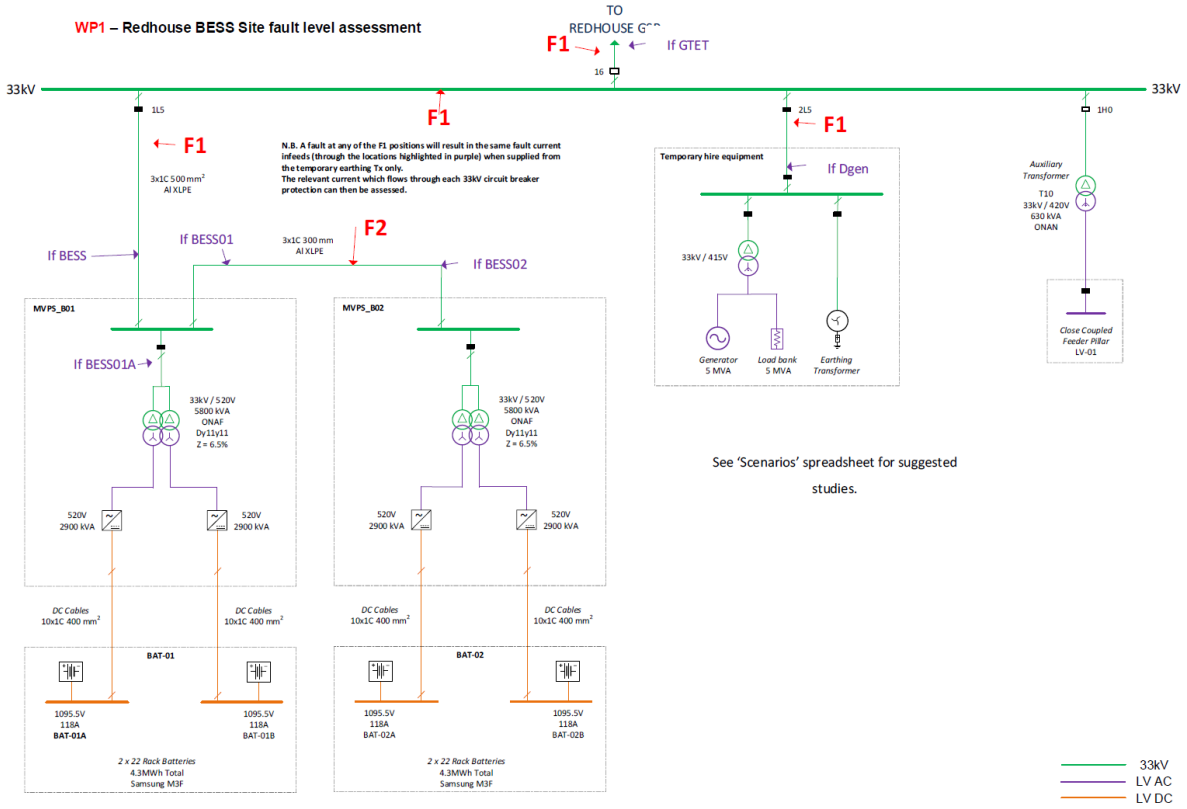

Figure 3.1: Redhouse Test Trial Network – WP1 Fault level Assessment

The table of results is included in Appendix A.

4 Conclusions

This report documents the fault levels calculated for eight scenarios for the purposes of setting the existing BESS system protection settings for a black start condition.

The fault levels are provided in Appendix A.

5 References

1. Power Factory Model LTDS v2018_2021-02-11 Redhouse BESS_20210622.pfd
2. BESS Transformer Spec provided 26/4/21 - B1021_DAT_TransformerMVPS5800_V02_Pre

APPENDIX A

Fault Levels

Scenario No.	Diesel Generator	BESS	Earthing Transformers		Fault Location	PRE-FAULT	L-L-L								L-L								L-G							
			BESS Site	REDH GT1			Total If		If Dgen	If BESS	If BESS01A	If BESS 01	If BESS 02	If GTET	Total If		If Dgen	If BESS	If BESS 01A	If BESS 01	If BESS 02	If GTET	Total If		If Dgen	If BESS	If BESS 01A	If BESS 01	If BESS 02	If GTET
							MVA	kA	kA	kA	kA	kA	kA	kA	MVA	kA	kA	kA	kA	kA	kA	kA	MVA	kA	kA	kA	kA	kA	kA	kA
1	ON	Grid Following (BAT-01A only)	IN	OUT	F1	1.0000	12.9866	0.2272	0.1758	0.0514	0.0514	N/A	N/A	N/A	14.6054	0.2555	0.1871	0.0687	0.0687	N/A	N/A	N/A	16.0761	0.2813	0.2299	0.0514	0.0514	N/A	N/A	N/A
2	ON	Grid Following (BAT-01A only)	IN	**IN**	F1	1.0000	12.9862	0.2272	0.1758	0.0514	0.0514	N/A	N/A	N/A	14.6033	0.2555	0.1871	0.0687	0.0687	N/A	N/A	N/A	20.4602	0.3580	0.2238	0.0648	0.0648	N/A	N/A	0.0962
3	OFF	Grid **Forming**	IN	OUT	F1	1.0000	11.7680	0.2059	N/A	0.2059	0.1029	0.1029	0.1029	N/A	20.3829	0.3566	N/A	0.3566	0.1783	0.1783	0.1783	N/A	35.3047	0.6177	0.2061	0.4116	0.2058	0.2058	0.2059	N/A
4			IN	OUT	F2	1.0000	11.7680	0.2059	N/A	N/A	0.1029	0.1029	0.1029	N/A	20.3829	0.3566	N/A	N/A	0.1783	0.1783	0.1783	N/A	35.3047	0.6177	0.2061	0.2061	0.2058	0.4118	0.2059	N/A
5			IN	IN	F1	1.0000	11.7680	0.2059	N/A	0.2059	0.1029	0.1029	0.1029	0.0000	20.3829	0.3566	N/A	0.3566	0.1783	0.1783	0.1783	0.0000	35.3041	0.6177	0.1220	0.4117	0.2059	0.2059	0.2059	0.1659
6	ON	Grid **Forming**	IN	OUT	F1	1.0000	21.8149	0.3817	0.1758	0.2059	0.1029	0.1029	0.1029	N/A	31.9841	0.5596	0.1900	0.3738	0.1869	0.1869	0.1869	N/A	30.3869	0.5316	0.2481	0.2840	0.1420	0.1420	0.1420	N/A
7			IN	OUT	F2	1.0000	21.8136	0.3816	0.1758	0.1758	0.1029	0.2787	0.1029	N/A	31.9839	0.5596	0.1900	0.1900	0.1869	0.3737	0.1869	N/A	30.3264	0.5306	0.2476	0.2476	0.1417	0.3890	0.1417	N/A
8			IN	IN	F1	1.0000	21.8149	0.3817	0.1758	0.2059	0.1029	0.1029	0.1029	0.0000	31.9841	0.5596	0.1900	0.3738	0.1869	0.1869	0.1869	0.0000	44.5080	0.7787	0.2567	0.3956	0.1978	0.1978	0.1978	0.2092

Table A.1: Fault Levels and Flows for locations F1 and F2 for Scenarios 1 to 8.

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