33kV Superconducting Fault Current Limiter

CET 1001 / LNCF-T1-001

Interim Closedown Report

December 2013

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Contents

1. Executive Summary

This project is to facilitate the faster connection of distributed generation (DG) from renewable sources at the distribution level, by mitigating possible fault current management constraints.

This is being achieved through the trialling of a superconducting fault current limiter at 33kV placed at the boundary of the transmission and distribution networks at a substation jointly owned by National Grid and Northern Powergrid.

This report contains the information mandated for closedown reports in Ofgem's Low Carbon Network Fund governance.

As the project is not yet complete this report details all of the outcomes of the project delivery process to date. All of the technical reports, milestone assessments, developed specifications, device modelling outputs, layouts, and required ancillary equipment have been included. Together these documents provide the full description of all of the issues requiring consideration and the decisions made..

The project status is such that all site surveying and selection, project and implementation design is complete. Building and civil site work is almost complete. Device manufacturing and final installation and commissioning are due to be complete during 2014. The issues that have led to the scheduling issues are discussed here.

The reports and documentation generated are very detailed and this report provides a brief summary of their content.

The interim learning outcomes are also detailed but these still need to be further assessed and confirmed following successful delivery of the project.

Based on the learning to date several firm recommendations with respect to the process of delivering such technology have been made.

With the experience from this activity, and a previous trial at 11kV, there is now sufficient confidence to specify fault current limiters as a standard network solution at 11kV. It is recommended that appropriate standards and policies are now generated to facilitate this within Northern Powergrid.

At this time it is still envisaged that the project will successfully deliver the learning required to fully understand the risks at 33kV and to generate the understanding required to use such devices at 33kV. The schedule for completing the project in October 2014 is presented.

33kV Superconducting Fault Current Limiter

2. Project Background

To facilitate the connection of distributed generation (DG) from renewable sources at the distribution level, the network needs to be capable of withstanding the consequential increase in fault level associated with such connections.

Strategically placed Superconducting Fault Current Limiters (SFCLs) could provide distribution networks with improved capability by limiting the fault current to within the rating of existing switchgear. The installation of SFCLs may allow for the accelerated connection of both renewable and non-renewable generation whilst reducing the need for major network reinforcement which is often required to cope with the increased fault level, typically before new DG can be connected.

Currently, a number of primary and supply point substations on the Northern Powergrid network have been identified as having a maximum switchgear duty greater than 95% of the make/break duty rating and this would be typical for the UK network as a whole. The connection of additional DG to these sites may increase the fault level beyond the switchgear rating.

3. Scope and Objectives

This project trials a specific piece of new equipment that has a direct impact on the operation and management of the distribution system.

The first phase was to identify suitable locations for the installation and undertake a feasibility and systems readiness study to analyse the network, outlining the optimum application and specification, and confirm the business and carbon cases.

The second phase was to design, build, install and commission a three-phase 33kV superconducting fault current limiter on the Northern Powergrid distribution network. It was proposed, and following site surveys, agreed with National Grid, that the unit was installed at a 275/33kV substation in South Yorkshire to limit the fault current to within the rating of the 33kV switchgear. This is currently managed through an operational management switching procedure which in some circumstances may increase the risk of loss of supplies to customers.

4. Success Criteria

The original project success criteria, as stated at project registration were as follows:

The project will be judged successful on completion of the following deliverables:-

- Robust carbon impact cases developed for different network scenarios
- Indicative business case developed
- Successful power system modelling of the unit
- Successful type testing of SFCL components
- Successful operation of SFCL, cryogenic cooler and auxiliary components
- Operational experience relating to the SFCL, cryogenic cooler and auxiliary components documented
- Network events and SFCL response captured electronically
- Running costs documented
- Maintenance requirements documented

- Identification of required changes to policy and operational documentation
- Successful dissemination of information and learning to DNO peer group.

4. Work Carried Out

The project is a collaborative activity with National Grid, Applied Superconductor Ltd (ASL), an SME based in Blyth, Northumberland, to produce a superconducting fault current limiter (SFCL) suitable for use at 33kV. Atkins has acted as the key design and installation contractor.

The project builds on previous work, conducted through IFI, and in collaboration with ASL, Energy North West and Scottish Power Energy Networks. This previous work designed, built and network-tested fault limiter units at 11kV. The project was evolutionary, with three different versions of the equipment being used. This project uses the latest version of the trialled technologies.

The project was not designed to provide a piece of business as usual, "field ready" equipment. The project's purpose is to investigate the option of using SFCL as an alternative to standard switchgear upgrade and reinforcement in circumstances where fault level is becoming a barrier to further connection of DG.

The project sought to take such a device through the process of specification, manufacturing, installation, commissioning and operation. The success criteria listed in section immediately above detail the key milestone stages in the process required to achieve the desired implementation.

The work carried out following the initial surveying phases of the project have included very close working with National Grid (NG) Electricity Transmission. The site chosen for installation was a site jointly owned with NG, the device actually being placed inside one of their compounds, necessitating a very high degree of co-operation between all parties

5. Project Outcomes

5.1 Current Status

The project is currently not complete. This report, in accordance with LCN fund governance requirements for projects reaching their third anniversary, is interim.

Designs, both for the device itself and for the site, have been completed. Site preparation, including all building and civil work on site is complete, as is initial electrical work.

Project work on site is currently suspended, awaiting outages on NG's supergrid 275/33kV transformer. Due to local loading and network risk conditions these outages are only available during British Summer Time.

The project is scheduled for completion at the end of October 2014.

The project plan to completion is shown in Appendix 1.

The stage-gate phasing of the project has allowed a substantial amount of learning to be identified and this is detailed in the project's working documents. The content and conclusions of these are summarised below.

5.2 Outcomes

Key outputs to date have been:

- Phase 1 completion report (Appendix 2)
- Network Impact Report (Appendix 3)
- Design Report Summary (Appendix 4)
- Modification Application for Jordanthorpe site (Appendix 5)
- Balance of Plant report (Appendix 6)

These documents are shown in the indicated appendices to this report and together capture the detail of the project learning to date. A short summary of the contents of each is given below.

5.2.1 Phase 1 completion report

Phase one of the project was designed to ensure that a complete and fully reviewed project plan was in place for the subsequent, substantive activities. There were several issues which could not be fully explored during the scoping and initiation phase of the project which needed to be understood before the project could be confirmed as viable. Pre-eminent amongst these was the need to fully understand project risk.

Phase one of the project specifically set out to identify:

- Circuit and site for installation;
- SFCL specification;
- Finalisation of the budget and project risk register;
- Identification and development of the processes required to produce the business and carbon cases;
- Identification of project success criteria and confirmation of learning approach for the project; and
- Identification of gate requirements for stage two of the project.

In general the requirements were met. The prosecution of the business case confirmed that the project appeared to be financially viable and that the product itself could potentially be viable as a piece of business as usual plant.

An in-depth assessment of potential sites was carried out, centred on the Sheffield 275/33kV ring. Following considerable discussion with NG, the site's joint owners, the Jordanthorpe site was selected for the device installation.

The criteria for this selection are detailed in the NGET briefing paper which is attached to the phase one report. Items considered include make and break duty of the switchgear at each location, current headroom available, the amount of physical space available plus other project risks such as scheduled engineering work in the locality during the project.

The project risk assessment and budget were confirmed, although in both cases as would be expected in a project of this type, these required review at a later date.

During phase one, an opportunity to use a postgraduate student to help develop the carbon case approach was identified. The quality of the output produced was poor and of insufficient quality to be used as a part of the project. This meant that the original intention to create a standard approach to carbon cases was not met. Subsequently this project requirement was overtaken by discussions at Ofgem's Innovation Working Group where a standard approach to carbon benefits was identified and captured as best practice.

5.2.2 Network Impact Report

This report details the following:

- Chosen network configuration;
- Zenergy modelling report;
- Identification of network modelling data;
- Required protection scheme;
- Test lab and network impact information; and
- Network loss assessment.

A key issue arose with the network impact loss assessment. The insertion loss of the SFCL, under normal, non-fault conditions, appeared to be higher than originally envisaged. This raised questions about the economic viability of the SFCL when compared with alternative technologies. As a result of this the project was temporarily halted whilst a full business case review and investment appraisal was instigated.

The ultimate conclusion of this study was that the non-fault insertion losses for the SFCL were not excessive, especially when compared with competing technologies, and that the degree of fault current clamping that the unit could provide was better than other technologies assessed, such as a series reactor. Carbon saving was also superior to all other options bar a full board replacement. On this basis the project, following review by the project board was allowed to proceed. The business case for the use of the SFCL will be reassessed at project completion using the recently established Ofgem cost—benefit framework developed for the ED1 well justified business planning process.

5.2.3 Design Report Summary

The Design Report was the output from that section of the project which was funded by ASL and not by the LCN fund. This was to ensure that any intellectual property rights generated here could be retained by ASL and not need to be put into the public domain. The central issue was the governance requirement of having to licence background IP to support any newly generated foreground IP. This could potentially compromise ASL's core technology and compromise the contractual relationship and licensing agreement with the ultimate technology owner Zenergy.

In the spirit of sharing learning ASL agreed to release a summary of the design report and this has been included as an appendix of this report.

This report details, sometimes at relatively high level, the device specification in the context of the local network, the general protection arrangements and the preferred site layout. Those elements of the work carried out here that have been retained by ASL include the internal device drawings and technical design aspects of how the SFCL, applying the company's core intellectual property, delivers the specification.

5.2.4 Modification Application

Following considerable investigation and discussion with National Grid, a modification application (mod. app.) was submitted in mid July 2011. This was in accordance with National Grid's TP105 self-build agreement as this was deemed the most appropriate methodology for the proposed delivery.

The document includes our final preferred configuration for connection of the device at the Jordanthorpe site, based on both the design impact report and previous site survey information from the phase 1 completion report. The analysis required to produce this document ensured that the issues around device location and connection within the compound were thoroughly explored. This has allowed a lower cost implementation than was originally planned at the end of phase one of the project, although that in itself was still above initial estimates.

The main reason for this cost reduction was site specific. An old transformer bund and compound was available at Jordanthorpe, close to the 275/33kV supergrid transformer and the preferred installation location. National Grid agreed that this could be used to site the device and allowed a bus-bar implementation rather than the cable connected version thought necessary earlier.

The preparation of the modification application and the associated discussions with NG identified the difficulties of trying to use standard business processes to deal with non-standard technology applications such as this. A high degree of interaction between all project participants has been required. This became more so with the increasingly tight schedule for the project.

The processes selected to manage the project is discussed in more detail later in this report

5.2.5 Balance of Plant Report

The balance of plant report is the final design report for the project. Together, with the previous reports this forms the final specification for the project, the device and the ancillary equipment used.

A full functional specification for the device and its installation is included. This also forms the specification for the project buildings and civils and forms a part of the contract with the key subcontractor Atkins.

The specification provides a description of the electrical network configuration and the works necessary to facilitate the connection of the SFCL, which includes the installation of a new 33kV circuit breaker, isolators and earth switches and associated protection. It represents the final embodiment of the project implementation and the culmination of the accumulated learning to the point that physical on-site work commenced.

The contract let was for the design, engineering, supply, delivery to site, off-loading, installation and erection, testing and commissioning, and site clearance. All of these requirements are shown as part of this report.

6. Performance against Original Project Aims

In terms of project content the project has performed well against the original aims. The practical issues associated with the specification, installation and commissioning of fault current limiters at 33kv have been thoroughly explored up to this point in the project.

6.1 Schedule Variance Analysis

Project performance against original schedule has been the key disappointment. The project was originally envisaged to deliver and install the device inside sixty-five weeks. The project has already taken twice this long with device installation not expected until October 2014.

The following table shows the original project schedule and associated milestones. For those parts of the project not yet complete the current planned date, according to the December 2014 schedule, is shown in the “actual” column.

			Delivery Week	
Phase		Phase Description	Baseline	Actual
1		Project Commenced –Down Payment	0	0
1		Phase 1 Complete	4	9
2		Phase 2 Set Up	5	11
2		Network Impact Report	11	26
2		SFCL Design Report (ASL internal cost)	17	
2		SFCL Material Procurement	18	40
2		BOP Design Report	27	80
2		SFCL Factory Test Complete	48	164 (planned)
2		SFCL Type Test Complete	55	164 (planned)
2		Commissioning Complete	65	210 (planned)
3		Project Close Down Report	119	220 (planned)

Several issues have been identified which have contributed to the overall project delay.

1. The impact of the use of an National Grid (NG) shared site, that is a 275/33kV substation, on the Sheffield ring was not correctly assessed at project planning. A shared site was selected to improve the learning output of the project, by exploring the necessary interaction with NG at the boundary, both technical and commercial of the transmission and distribution networks. Furthermore the fault level impact where the 132kV intermediate voltage was absent was likely to be of more interest for the project. However the complexity of the specific site chosen and the nature of the construction and electrical design required both additional cost and time to allow implementation.

   It was anticipated that much of the network impact assessment work could be undertaken without making choices about the precise site that would be used. This proved not to be the case and initial discussions with NG were required before several key decisions could be made. This impacted the project critical path.

2. A second issue arose following the design report milestone for the project. It was thought that the insertion losses for the SFCL device would be low to the point of being negligible. Once the design modelling and assessment exercise had been completed it became clear that this would not be the case. Under these circumstances it was necessary to revisit and reassess the original business and carbon cases for the project to ensure that it was economically sensible to take the project forward.
3. Up to this point the expended costs had been relatively low but the acceptance of the design report would instigate major expenditure associated with the actual building of the equipment. It was therefore deemed prudent to ensure that the new situation and risks were adequately assessed and that key stakeholders, primarily the project partners and Ofgem, had been consulted before the project went forward. The additional tasks and time taken to consider the analysis introduced a further delay project schedule.

Two further delays were introduced by issues at the SME supplier of the equipment Applied Superconductor (ASL).

4. The supplier of the core technology for the SFCL device, Zenergy, made the decision to cease business and went into administration. This had two major effects both of which impacted on the project delivery schedule.

   Firstly the technology required to complete device manufacture was no longer available. After considerable negotiation, across three continents, ASL eventually acquired the rights to the technology by buying Zenergy's IP portfolio and securing some of the key personnel.

   Secondly the device's magnets, which were being produced by Zenergy, and were within a few days of completion, were sent for scrap by the administrator. This was despite extensive negotiations over several weeks to secure these key components. This required ASL, once the IP had been obtained, to identify a new manufacturer and having to rebuild the components from scratch. Furthermore the new manufacturer was less familiar with the technology than Zenergy had been. This lengthened the lead time for the magnets compared with the original plan and further compounded the already considerable delay in the SFCL delivery.

In parallel with the ASL process to secure the underlying technology consideration was given to the use of alternative fault current limiting approaches not requiring superconducting magnets. The differences in the device properties and capabilities compared with the core technology around which the project had been designed eventually ruled out this option. In effect the project would have been new, with both the "problem" and the potential "solution" to the problem, as defined in the LCN fund project registration governance requirements, being different to that originally envisaged.

Together these processes associated with the loss of Zenergy added around 45 weeks to the overall project schedule.

Taken all together these several different issues added around 75 weeks to the original project schedule. It became clear that the project would not be complete within three years required by the LCN fund governance but that it was still possible to complete the device installation, and thus the bulk of the expenditure, within that time. Ofgem were advised of this in January 2013, at the same time pointing out that there remained a considerable risk, given that there was no slack in the project schedule, of missing the three year limit if there were any further delays.

In late July 2013 one of the components of the SFCL failed during routine quality and technical testing at the manufacturers. The need to perform some re-manufacturing introduced a four month delay in the delivery schedule.

This delay had a severe knock-on impact with respect to re-scheduling. The location for the device installation requires super-grid transformer outages arranged through NG's year-ahead booking system. The outage slots booked for late August 2013 could no longer be met.

Furthermore such outages are only available during summer time, whilst the UK is on British Summer Time due to load related unplanned outage risk. Although the SFCL will now be available in early 2014, having completed manufacturing and testing, suitable outages cannot be secured until late July 2014, with a scheduled commissioning date in September 2014. The site works will then be closed down for the end of October 2014.

As the SFCL was scheduled to be installed during August 2013 the building and civil work was well advanced and approaching completion. In order to suspend the project safely the site works was continued to the point at which both NG and Northern Powergrid could be satisfied that the site posed no risk and met all statutory health and safety responsibilities. The site was closed down in October 2013 and is currently scheduled to be re-opened in May 2014.

No modifications have been made to the planned approach, either "problem" or "solution" during the course of the project. Milestone reviews at key decision points have been undertaken and the project has been re-assessed at those times.

6.2 Cost Variance Analysis

The original project registration with Ofgem was for eligible, recoverable spending of £2,880,000, equivalent to a total project value of £3,200,000, once the business contribution of 10% is accounted for. This sum included £2,600,000 of disbursed spending to ASL for the SFCL and £600,000 for installation design and delivery costs.

The current project forecast outturn value is £3,486,000 which gives an LCN fund project value of £3,141,000. This is a variance of 9.1% compared with the original registered value.

					Variance
Item	**Initial Assessment**	**Current Forecast Out-turn**	**Spending to date**	**Remaining expenditure**	**Against initial**
33kV SFCL	£2,515,000	£2,515,000	£2,333,000	£182,000	£0
Aux transformer	£20,000	£8,306		£8,306	-£11,694
Building and Civil works	£163,861	£156,953	£156,953		-£6,908
C&E Design		£114,513	£114,513		£114,513
Cables & conductors	£231,862	£241,524	£121,136	£120,387	£9,662
Cable Installation	£37,336	£32,207	£22,200	£10,007	-£5,129
Circuit Breakers	£125,000	£92,028	£92,028		-£32,972
Earthing, multicores, protection and commissioning	£57,174	£139,696	£89,690	£50,006	£82,522
Project set up	£9,593	£11,526	£8,717	£2,809	£1,933
Site welfare	£4,557	£43,731	£33,031	£10,700	£39,174
Modification Application/Design	£0	£35,000	£35,000		£35,000
Contingency	£35,617	£0			-£35,617
Internal project management		£96,000	£61,000	£35,000	£96,000
Total	**£3,200,000**	**£3,486,483**	**£3,067,267**	**£419,215**	**£286,483**

The original estimates for the project included contingency for building and civil works, these were originally estimated by comparison with similar projects, at a value of around £500k. As the project has progressed this has increased significantly and now out-turns at £800k.

At project inception it was necessary to make some estimates of project costs. The magnitude of any spending required would not be known until some of the early project milestones had been delivered. In particular the network impact report and the design milestone report were significant in this respect as they defined the site that was to be used and detailed the precise installation configuration.

Our initial estimates required some refinement, primarily as the result of the decisions taken around installation location which had been taken to enhance project learning.

Once these assessments were complete, in September 2011, our worst-case assessment of costs at this time suggested that a total budget allowance of around £4.1m would be appropriate. This assumed that a relatively large amount of protection would be required around the device to satisfy NG operational and network risk requirements

The nature of the project demanded a relatively large degree of contingency. This assumption was by no means certain but formed the basis of the project's re-assessment of costs which, in turn, were used as the basis of the investment appraisal for the project when it was re-authorised following the end of phase 1.

Additionally efforts to reduce project costs were made. Subsequently we were able to reduce the concerns that NG had regarding the device and design an improved installation requiring less protection equipment. This bought down the expected cost considerably and the current project budgeted outturn is £3,486,000.

7. Lessons Learnt for Future Projects

A considerable amount of experiential learning has been developed regarding the way this type of project needs to be managed. This learning has an impact both on the way future projects should be run and on the facilitation of replication.

Standard commercial and technical boundary definitions need careful consideration

The use of a jointly owned site has been particularly informative in identifying implementation details which would not have apparent had the option for a Northern Powergrid site been taken.

A key issue has been the nature of the system interface between the transmission and distribution networks and the ownership boundary.

It is not possible to conduct a project of this type if the boundary between the systems is considered to sit at the ownership boundary. For maximum effect, and therefore cost benefit, the device needs to be embedded in National Grid's network. This is the case for both this project and for future similar installations.

The benefit of the device is on the distribution network but the installation is on the transmission network. As well as for this specific device, this is likely to be the case for other types of technology in the future which improve the overall effectiveness of the system as a whole. This would indicate that new technical, operational and contractual arrangements will need to be developed to allow the cost effective evolution of the total network system to accommodate low carbon technologies or other approaches to maximise value for money for the customer.

One of the significant issues that arose from the nature of the boundary was for the type registration of equipment. Type registration is required for equipment on the National Grid network but such registration is often not available for 33kV equipment, for which National

Grid does not generally have a requirement. Specific type registration issues for key equipment are discussed further in the section below on the facilitation of replication.

For this project the installation boundaries and how the various responsibilities were allocated can be summarised as per the following table:

	Standards	Ownership	Operational
Civils	National Grid	National Grid	National Grid
Fault current limiter	National Grid	Northern Powergrid	National Grid
Isolators	National Grid	Northern Powergrid	National Grid
Bypass breaker	National Grid	Northern Powergrid	National Grid
Low voltage supply	National Grid	National Grid	Northern Powergrid
Protection - Bypass	National Grid	Northern Powergrid	Northern Powergrid
Protection - Trip	National Grid	National Grid	National Grid
Maintenance	Northern Powergrid	Northern Powergrid	Northern Powergrid
National Grid Scada	National Grid	National Grid	National Grid
Northern Powergrid Scada	Northern Powergrid	National Grid	Northern Powergrid
Safety	National Grid	National Grid	National Grid
Power quality meters	National Grid	Northern Powergrid National Grid	Northern Powergrid National Grid
Magnetic field	National Grid	Northern Powergrid	National Grid
Land	National Grid	National Grid	National Grid

The project has been able to overcome these boundary issues, mostly as the result of very close working between the Northern Powergrid, National Grid, ASL and Atkins teams. It seems unlikely that this level of personnel, and therefore the degree of oversight, would be applied for business as usual implementations and a standard approach needs to be agreed to avoid this. The final embodiment of this is likely to be a complex commercial and legal issue. The project will consider it further following successful completion of installation and commissioning, but such an agreement itself, beyond the identification of need, probably sits outside of the scope of this project.

A shared technical vocabulary needs to be developed early

Another issue that became apparent as the project progressed was that there was no standard way of showing a network asset of this type on network drawings or indeed naming the device. Whilst this was relatively easy to overcome it is likely to be the case with any new type of asset developed through either an LCN fund or, under RIIO, a Network Innovation Allowance project and is an issue that needs to be addressed early rather than later in the project schedule.

8. Planned Implementation

As the device implementation is not yet complete no recommendation on device installation at 33kV can be made yet.

Whilst the project is not due to be completed until the final quarter of 2014 a lot of learning has been generated particularly with regard to the circumstances under which an SFCL might be specified and used. Further useful experiential learning has come from the project journey and recommendation based on this learning that allow the facilitation of replication are given in the section below..

Together the experience that we have gained through the implementation of the 11kV SFCL device we now have sufficient confidence to recommend 11kV fault current limiters in general for use as a business-as-usual option for those areas on the network where fault level capacity is constrained and a good economic case can be made against alternative mitigation. The learning gained will be used to create appropriate standards and design policies during the first half of 2014.

It is expected that this confidence will be further supported by the completion of the 33kV implementation and it is anticipated that, assuming a successful outcome, a similar recommendation regarding business as usual use at the higher voltage will be made at the earliest possible time.

9. Facilitation of Replication

All of the key design documents that are required to replicate the outcomes of the project are included in this report. The key technical decision making is generally included in the milestone reports, which are attached to this report as appendices.

Together these documents capture the outcomes of the project to date and, together, represent a guide to implementation of the project so far.

It needs to be appreciated that since the project is not yet complete it has not yet been possible to confirm the decisions made and set out here. The assessment of the quality of those decisions and therefore the usefulness of those for informing the learning for subsequent implementations is not yet known.

This will be fully evaluated once installation and commissioning is complete. However the project is already able to make several recommendations.

9.1 Process Adopted

The process of engaging with National Grid with respect to design and project assurance is complete, although still subject to final review.

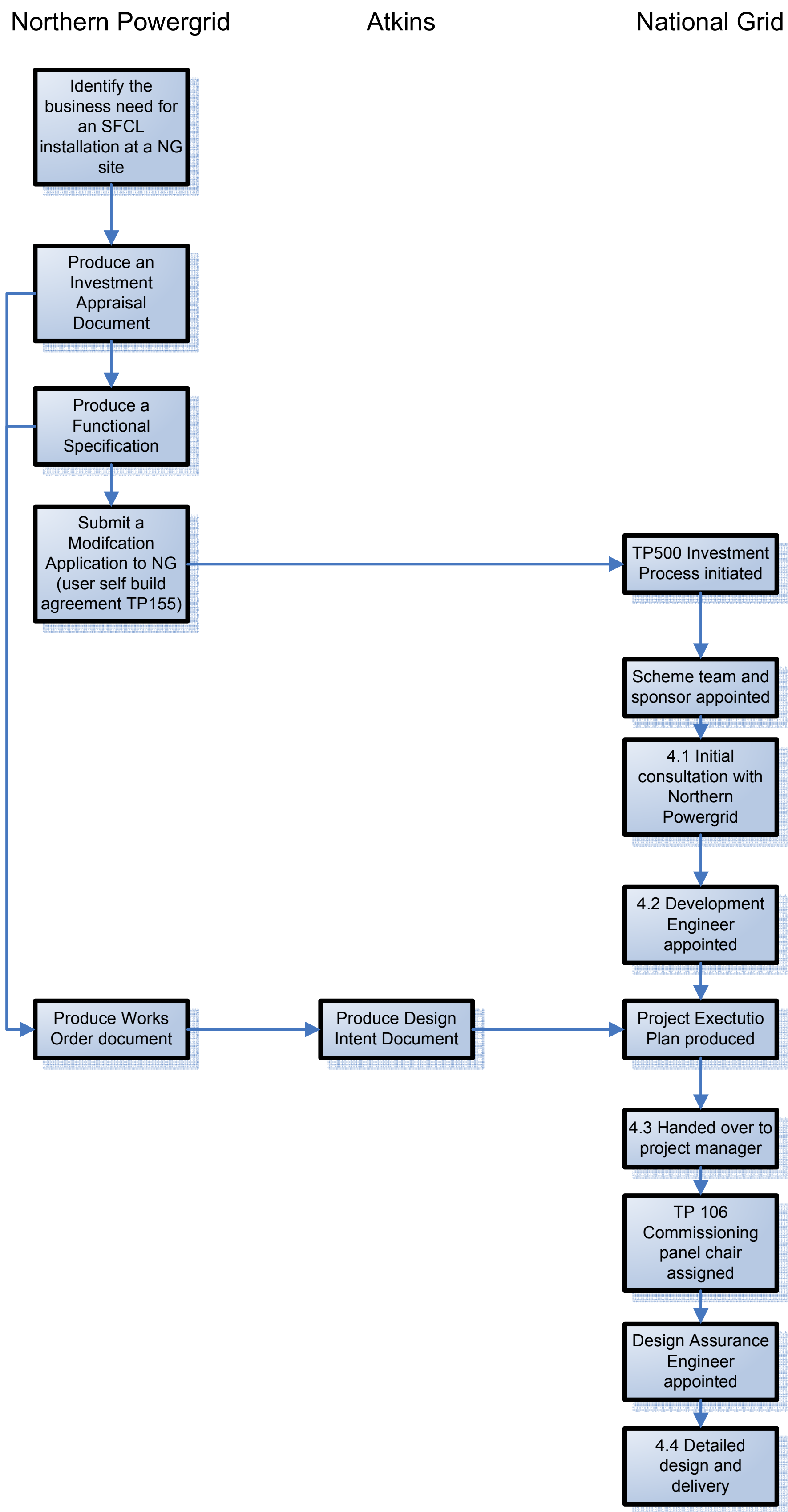
The project has generally used National Grid procedures for this due to the physical location of the device on the jointly owned site – that is on the NG side of the property boundary. The adoption of this process has proved to be extremely useful in ensuring that all of the complex arrangements for a project such as this have been adequately captured and addressed. Furthermore the use of this framework has provided clear visibility of project requirements to the supporting teams from the various businesses, as well as to the core team. This is important in a project of this nature and is recommended for further applications of this specific technology or other similar projects.

The overall process adopted was as shown in the flowchart shown on the following page.

The key document that captures the agreed elements of the design is the design intent document (DID). This feeds into National Grid's Investment process, TP500. The DID lays out the key arrangements that embody the full set of final design decisions. The DID is attached to this report as Appendix 7 and details the following:

1. Design Team list
2. Related documentation and drawings status
3. Scope of work
4. Substation HV equipment
5. Protection, control & telecommunications
6. Civil, structural and building engineering
7. Overhead line
8. HV cables
9. Substation Design Specification (SDS)
10. Contract Drawing Schedule (CDS)
11. Procedural requirements

As such it provides a summary of all the technical design decisions and their impact on the actual physical requirements to implement and a summary of key considerations for future implementations.


Northern Powergrid
Atkins
National Grid
Identify the business need for an SFCL installation at a NG site
Produce an Investment Appraisal Document
Produce a Functional Specification
Submit a Modifcation Application to NG (user self build agreement TP155)
TP500 Investment Process initiated
Scheme team and sponsor appointed
4.1 Initial consultation with Northern Powergrid
4.2 Development Engineer appointed
Produce Works Order document
Produce Design Intent Document
Project Exectutio Plan produced
4.3 Handed over to project manager
TP 106 Commissioning panel chair assigned
Design Assurance Engineer appointed
4.4 Detailed design and delivery

9.2 Type Registration

A related issue was that of type registration.

It is generally a requirement that equipment installed on the NG system is NG Type Registered. Consideration was given to this requirement in respect of each of the following pieces of equipment:

1. The SFCL device
2. Bypass circuit breaker
3. Disconnectors
4. Power quality meters
5. Protection relays

SFCL - As a developing technology within the context of an innovation project, the cost of undertaking full type registration of the SFCL device was assessed to be prohibitive, however the SFCL device followed the type registration process as much as was economically practical..

Type tests, broadly conforming with IEC 60076 Part 6 Clause 8 for series reactors and NG document TS3.2, were agreed with NG who were invited to witness type testing.

The benefit of this approach was that through collaboration between NG and ASL, the standards most relevant to the SFCL were identified and interpreted to pragmatically set the required standards for SFCL technology.

Bypass circuit breaker -As NG rarely procures 33kV rated equipment, no 33kV circuit breakers have been NG type registered. It was therefore necessary to specify a 72.5kV rated circuit breaker that had been NG type registered. This impacted on the cost of project implementation.

Following procurement of a circuit breaker that was believed to be NG type tested, it subsequently came to light that a spring mechanism modification had been undertaken by the manufacturer on the circuit breaker and consequently the type registration was no longer valid for the product. This was taken up with NG and derogation was agreed for the 72.5kV circuit breaker.

Disconnectors - As with the circuit breakers, it was necessary to procure 72.5kV disconnectors that had undergone NG type registration. 72.5kV units were procured with the required type registration EGI code.

Power Quality Meters - The power quality meters were specified by NG. These devices are the latest generation of quality meters previously installed by NG. Type registration had not been undertaken by NG on the new products at the time of project delivery.

Protection Relays - Type registered protection relays were procured, but an intellectual property issue prevented the manufacturer including the type registered relay configuration. To overcome this, the configuration was obtained from another NG installation.

Implications - Several items of equipment making up the installation have not been type registered as would normally be required. In the spirit of the collaborative innovation project, derogation has been provided by NG following appropriate referral to specialist colleagues. The installation of an SFCL in a business-as –usual scenario would require that the device itself and all associated equipment are appropriately type registered.

Mitigation - The requirement for NG type registration could be overcome if the ownership boundary was changed such that all the equipment is owned and operated by Northern Powergrid. This would enable Northern Powergrid assessed 33kV products to be specified in the design.

As discussed previously changes of boundary ownership would not have been straight forward, or economically sensible, in the case of this project. The significant cost benefit in installing the SFCL and associated plant within the NG compound, allowing busbar connection of the SFCL, bypass circuit breaker and disconnectors determined that the equipment would be placed under NG safety rules and any consequences would need to be managed on a case by case basis.

Consideration could be given by ASL to undertake type registration of an appropriate 33kV breaker for use in future NG system applications, and thus present a complete installation package. This will be given more detailed consideration once installation is complete along with the other issues of the impact of ownership boundaries and responsibilities.

10. Progress To Date Against Original Success Criteria

Deliverable	Status	Comments
Robust carbon impact cases developed for different network scenarios		
Indicative business case developed		
Successful power system modelling of the unit		Included in Design Report.
Successful type testing of SFCL components		Underway, due to be completed December 2014.
Successful operation of SFCL, cryogenic cooler and auxiliary components		Underway, due to be completed December 2014.
Operational experience relating to the SFCL, cryogenic cooler and auxiliary components		Requires completion of commissioning.
Network events and SFCL response captured electronically		Requires completion of commissioning.
Running costs documented		Requires completion of commissioning.
Maintenance requirements documented		Not started but should be available before commissioning, based on the 11kV
Identification of required changes to policy and operational documentation		To be assessed following commissioning.
Successful dissemination of information and learning to DNO peer group.		Some initial dissemination through LCNF conference and ENA R&D working group.

11. Next Steps

The key planning milestones for the remaining part of the project are:

Milestone	Date
SFCL Electrical Testing	20/12/2013
Re-open site, restart preparatory work	12/5/2014
SFCL on-site	9/6/2014
Installation and commissioning outage commences	14/7/2014
SFCL Energised	15/8/2014
On-site work complete	3/10/2014

After this date it is currently intended to maintain the device at Jordanthorpe for three years beyond project completion to generate the maximum amount of learning about the behaviour of the SFCL under a variety of network conditions and events. Although this sits outside the project boundaries it is the intention of Northern Powergrid to continue to disseminate this additional learning as it becomes available.

12. List of Appendices

Appendix 1 : Revised Project Schedule, as at 1st December 2014

Appendix 2 : Phase 1 completion Report

Appendix 3 : Network Impact Report

Appendix 4 : Design Report Summary

Appendix 5 : Modification Application

Appendix 6 : Balance of Plant Report

Appendix 7 : Design Intent Document (DID)

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Appendices

Appendix 1 – Network Impact Report

Appendix 1 - Project plan SFCL 2014.pdf

Appendix 2 : Phase 1 Completion Report

Appendix 2 - Phase 1 completion report with attachments.pdf

Appendix 3 : Network Impact Report

Appendix 3 - Network Impact Report.pdf

Appendix 4 : Design Report Summary

Appendix 4 - Design report summary with attachments.pdf

Appendix 5 : Modification Application

Appendix 5 - Modification Application.pdf

Appendix 6 : Balance of Plant Report

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Appendix 7 : Design Intent Document (DID)

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