400kV and 275kV Telecomms Resilience Project - OFGEM justification paper	
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1 Introduction

The SP Energy Networks (SPT) Telecommunications network supports a range of critical services that are required to ensure safe, reliable and secure electrical network management. The services include the following aspects:-

- Provide protection signalling to protect people and assets in the event of faults
- Provide Supervisory Control and Data and Data Acquisition (SCADA) monitoring for the transmission network
- Provide operational telephony across the control rooms and sub-stations
- Provide the capability to transfer data for applications such as security management, detailed electrical phasor point measurements and support the growth of the distributed generation activities.

SP Energy Networks has proposed a range of improvements in the Telecommunications network. These are designed to refresh the existing apparatus, align with industry recommendations and practice for critical network infrastructure resilience, deploy an increased level of fibre optic communication medium and ensure that the network capability meets the current and future requirements.

This paper proposes a range of works to rationalise the technology used for the service provision, ensure that the technology is secure and supported for use and enhance the resilience of the telecommunications network. This network provides critical services for the main interconnected 275kV and 400kV systems. The proposal will ensure that there are no single points of failure which leaves the transmission system vulnerable to significant disruption.

A comparison was also made to the other Transmission Operators (TOs) and their design of the Telecommunication Networks for these services. This was to confirm that the policies within SPT were consistent with the other TOs that determine the requirements of the telecoms network, and that the design of the telecoms network was also consistent with those TOs.

A review was also held with WSP, a large independent engineering consultancy, to validate the approach and ensure that this was consistent with engineering practices.

The works will be carried out progressively over the RIIO-T2 period to maintain continuity of service.

2 Background Information

2.1 Outline of Network Requirements

The telecommunications network is the foundation for critical safety and operational services across the electrical network. The requirements become more stringent to support these critical services as the voltage levels increase. The services that this network supports include tele-protection, network monitoring, control, supervision, data acquisition, operational telephony and security features such as Closed-Circuit Television.

It can be considered that the main driving factor for resilient telecommunications in the network is the requirements of tele-protection. These requirements become more onerous as the voltage levels increase. The corresponding telecommunication requirements to support this safety critical function also become more onerous, with a high-quality service being required. This high-quality service includes a low latency, high availability service which results in an overall resilient network.

2.2 Network Topology

SPT do not currently operate duplicated communications provision for their 275kV and 400kV sub-stations. To date, SPT has operated on the lower cost principle of utilising carrier class telecoms equipment with minimal single point of failures for active equipment for those services that are required to be diverse from each other, such as protection services. This also applies to services with a requirement for resilience, such as RTU main and standby routes.

The network has elements of dual redundant features such as dual power supplies, dual control processors and dual switch fabrics. However, operational experience has shown that there can be significant loss of protection services under certain scenarios.

The existing network uses a central ring topology to provide connectivity with “spokes” from this central ring to other sub-stations. There are operational experiences that have shown that the current network topology is not fully resilient under specific cases.

This has shown the overall weakness in the current practice that this paper is attempting to resolve. This proposal is to address these inherent vulnerabilities rather than solely consider the failure rates of equipment.

2.3 Technology Description

The telecommunication network that is used has evolved as the technologies that are available has also evolved. There are currently three different technologies that are used to provide the required services on the network. These have been utilised and developed for different purposes and practices.

The original technology used was Plesiochronous Digital Hierarchy (PDH). This technology is used as it is generally reliable and can be used for some protection services. The technology is quite old and can be considered a niche market, with a limited range of suppliers. Currently, there is only supplier that can provide the specific equipment used by SPT and there is uncertainty over how long this supplier will continue to provide a service.

The next technology used is Synchronous Digital Hierarchy (SDH). The current SDH network supports the tele-protection and inter-trip services of SP Transmission which are currently deployed with minimal single points of failure, support for low latency signalling, primary and secondary routing paths, and black start power source resiliency.

The final technology that is deployed is Multiprotocol Label Switching (MPLS). There are two variants of this on the SPT telecommunciations network, but these are considered to be identical in the advantages of this technology. The technology can automatically change the routing under a fault condition. In addition, the information that can be returned from the technology devices is substantially greater and hence the ability to remotely manage the network is substantially greater.

The present SPT telecommunications network utilises all three technologies (ie PDH, SDH and MPLS). However, they are at different stages of age and support capability. The manufacturers identify two stages of life. The first is that the product is at End of Life (EOL) and this means that the product is no longer marketed or manufactured. This obviously gives issues such as spare holding capability. The second stage is End of Support (EOS). This is when the manufacturer will no longer offer any technical support including fault rectification, cyber security patching or updates to the equipment for reliability improvements.

The SPT network has assets of varying planned and remaining life which is complicated by the nature of the products. The newer technologies generally have a shorter life from the manufacturers. This is due to the increased complexity and the difficulty the manufacturer has in supporting multiple versions of products. This is a complicating factor in the assessment of investment decisions.

3 Comparison to other TOs

A review of the other Transmission Operators on the design of their telecommunications network has been undertaken. This has included discussions, a review of the Telecommunication submissions and further discussions on the network implementation.

The submission from National Grid referenced the following points

We have engaged widely with relevant stakeholders to consider future requirements of the telecom's networks, engineering alternatives and solutions. Specifically, we engaged with other Transmission Operators in the UK electricity system at Scottish and Southern Electricity Networks (SSEN) and Scottish Power Energy Networks (SPT) to validate the rigorous engineering standards applied to the provision of the telecoms solution. It was confirmed that SSEN and National Grid applied virtually identical engineering approaches to the provision of operational telecoms, and SPT were updating their standards to align to National Grid and SSEN standards

SSEN outlined in their submission that they were further developing dual, resilient fibre connections to sub-stations.

The information from National Grid, in particular, has outlined that SPT have a different standard to the other TOs. On examination, and given the arrangement of the telecommunication networks, it is evident that SPT have a lower resilience currently to that of National Grid and SSEN.

4 Outline of Analysis

The approach on the assessment of the network was to understand the current performance of the network and the future life issues that will result due to equipment ageing. In addition, a review of significant incidents was undertaken to further understand where the network did not provide the required level of resilience.

This paper will present the following information

1. The historical fault performance of the telecommunications equipment on the Transmission network.
2. The life of the telecommunication equipment on the network and options
3. A review of specific faults to highlight significant loss of the network
4. Specific issues to be addressed
5. Option assessment including costs

The network topology changes have been detailed using a specific case study to explain the issues identified and the proposed solution. It is emphasised that the detailed analysis was undertaken on more faults, but one has been selected solely to limit the size of the paper.

5 Impact of telecommunication faults

The impact of a telecommunication failure can be difficult to fully ascertain. This is entirely dependent on the services that are impacted and the corresponding electrical network conditions at the time of the failure. One of the key aspects is that a telecoms failure can affect Transmission circuit protection, and this results in power line circuit or circuits having to be switched out in line with the operational practices. The loss of protection would result in a potential health and safety issue and/or the power system equipment can be placed at risk due to extended fault clearance times.

The impact of the loss of Transmission protection can result in 3 main issues as below.

1. If the protection depletion occurs during a period of high wind generation, it can result in the Electrical System Operator (ESO) having to pay substantial constraint costs to manage the network flows. This would not be known to SPT as it is the responsibility of the ESO to manage this aspect of network operation.

2. If the depletion affects a radial transmission circuit, it will affect the security of supply to a Grid Supply Point (GSP) or group of GSPs. The impact of this could range from 10,000 customers to over 100,000 customers depending on the network configuration at that time.

3. The worst case of this is if the telecommunication issues affects the protection equipment associated with the 400/275kV Main Interconnected Transmission system across the major system boundaries. Under this impact, this can affect wider GB network security of supply given the implications on availability of cross-boundary circuits and the associated power flows.

The telecommunications network also carries a number of other services and the failure of the network would result in the following impact as below. While these are less critical than the protection services highlighted above, they are important to the safe and reliable operation of the network.

1. The loss of visibility of the network. The control room (and by extension, the ESO's control room) manage the network through information being received from Remote Terminal Units (RTUs) that pass messages back to the control system. This would be unavailable for the affected section of the network.

2. The loss of control of the network. In a similar way to the visibility, control signals are passed to the plant utilising the telecoms network. Manual control would be required to facilitate the operation of the network. This manual control would require staff to be deployed across the affected substation locations. This would compromise the response to any event that arise and would affect the overall management of the entire network, not just those affected sites.

3. The loss of local sub-station telephony. The telephony in the substations is operated using the telecoms network. Failure of the telecoms network could potentially be a safety issue as it removes a form of emergency communication from the field to the control room or the reverse.

4. The loss of the physical security measures at Transmission sub-stations affected. The closed-circuit television security management utilises the SPT telecommunications network to carry the data to the Security Centre.

The impact of the above points is again dependant on the nature of the fault, the exact services affected, the length of the outage time and external factors at the time, such as weather or the political climate.

6 Historical Fault Performance of the network

SPT utilise Vodafone as a Managed Service partner for the telecommunications network. In this regard, Vodafone have responsibility for the fault rectification and service reporting. SPT have a team of engineers who oversee and manage the work that Vodafone undertake.

When a telecoms network issue occurs, an engineer in the Vodafone managed Network Operational Centre (NOC) reviews the information in terms of alarms and the symptoms of the loss of the network. There are different repair options that can be completed, which could include sending an engineer to site to investigate and rectify problems.

There are a range of potential issues that may cause a loss of service on the network. These include third party issues (such as BT issues), local power supply problems, third party damage to fibre, weather (for radio systems as an example) and site hardware issues.

When the work is completed, there is a closure process with the engineer completing an incident cause. These can range from a requirement to reset the equipment, through to third party damage, power supply issues at the site or a specific equipment hardware fault.

For the purposes of this paper, the focus was on site hardware issues as these relate to the overall robustness and resilience of the network. The following table, Table 1, was prepared from the information from Vodafone. The records run from 2016 (full calendar year) through to 2019 (full calendar year). This data was reviewed and verified by SPT both at the time of the incident and for this assessment.

Incident Cause	2016	2017	2018	2019
Site Hardware fault	50	63	58	37

Table 1: Failure records for site hardware

An assessment was made on the repair times. However, this was considered to be misleading as this does not necessarily equate to loss of service. It is possible to change the route of the service ("re-route") and to restore the service while the repair is progressed. The time to restore service is not just assessed as the repair time itself is the metric used internally.

Similarly, while there are other failures that would affect the SPT Telecommunications network such as pilot cable faults, these were also excluded for the purposes of this assessment for the same reason, namely that there could potentially be a re-route option to restore service.

The failure rates above indicate that there are faults on the network with the current equipment and each of these faults will equate to potentially some form of loss of service. Some form of replacement or equipment rationalisation would be required to reduce the volume of faults and hence the transmission system impact.

7 Assessment of equipment ageing

There was an assessment made of the equipment ageing on the network. As outlined in Section 2, there are different stages of life assessment that can be made, End of Supply and End of Support.

The manufacturers generally only provide the End of Supply date. The End of Support date is advised following the passing of the End of Supply date.

The strategy that SPT has adopted has been to run the equipment past the End of Supply and try to optimise the life as far as possible before the equipment moves beyond of End of Support. The position is further complicated by the requirement to have management platforms and supporting infrastructure that allows the equipment to be managed in an effective and efficient manner.

The table below, Table 2, indicates the current position. It can be seen that the PDH and SDH equipment has been sweated through RIIO-T1 but will require replacement within RIIO-T2. The IP (MPLS) network will become end of life through RIIO-T2.

RIIO-T2 275kV and 400kV Networks	Percentage of Equipment End of Supply	
	01/04/2021	01/04/2026
SDH (Cisco)	100%	100%
*Nokia(Avara) PDH	57.5%	81.5%
MPLS Network	1%	100%

Table 2: End of Supply status for assets

*There is no published End of Supply date for Nokia but this is based on a life of 15 years which is typical for this type of technology

If the SDH and PDH equipment is not replaced within RIIO-T2 then SP Energy Networks cannot guarantee the maintainability of the network based on lack of equipment supply and also the availability of SDH/PDH skilled engineers from the suppliers. If the investment is delayed until RIIO-T3 then the SDH and PDH equipment will need to operate until 2031 which may result in critical outages of the electrical network as equipment fails. This will also restrict the ability to support initiatives such as 275kV Digital substations with no SDH equipment potentially available to expand the SDH network or to support the new industry protocols and cyber-security initiatives.

The MPLS network is an Internet Protocol (IP) based network. This provides significant additional functionality and ease of use. It also, by the basis of its operation, is significantly more reliable in that it can automatically change routes. However, the main issue for SPT with this protocol is that it offers a clear attack vector for a cyber security attack based on the IP nature of the technology. This means that support for the product is critical for any updates to the product to protect vulnerabilities. The Network Information and Systems (NIS) Regulations require SPT to consider and manage cyber security risks. This requires the implementation of the correct patching regime, requiring vendor support.

The status of the existing technology, largely being end of Supply, coupled with further developments in the technology, allow SPT to evaluate different options for the asset refresh/replacement. The options include the continued replacement of the existing technologies or migrate all of the services carried on these three technology stacks to a single technology, ensuring efficiency.

One aspect that has limited deployment previously has been the sensitive nature of electrical protection to communication disturbance even for short durations (sub-second). However, the new technologies now on offer allow services to be seamlessly switched without mal-function. However, this will require additional fibre deployments to ensure that the new technology can be deployed effectively.

8 Significant Fault Events

It was identified in Section 6 that while the equipment could have stopped operating, it did not necessarily result in a loss of the critical services. A review was held on more significant demonstrable impacts on the electrical network to quantify and assess potential improvements. The incidents are outlined below in Table 3. These were used to assess the direct impact and improvements that could be made. While the specific incident was at a specific site, it was considered that these could have happened at any site in the future given the common architecture in use.

Date	Location	Cause	impact
13/9/2019	Kaimes	Failed Multiplexor	The visibility of 22 sub-stations were lost. In total, 52 protection services between 38 sites were lost
29/10/18	Longannet	Fire	The following transmission circuits were switched out of service due to the associated loss of protection, impacting major system boundary B4. • Longannet – Westfield • Mosmorran SGT1 • Easterhouse SGT1 • Windyhill SGT2
8/2/2018	Stirling - Devonside	Damaged Fibre	26 protection services were affected. The following circuits were also affected DEVO T2 and 120 opened, WFIE 120 opened DENN-LOAN 2nd main protection blocking switched out EERH-LOAN 2nd main protection blocking switched out KINC – CURR 2nd main protection blocking switched out
18/10/17	Westfield	Site hardware failure	The following protection was switched out: Longannet – Westfield 2nd Main Protection Longannet – Denny 2nd Main Protection Blocking Kincardine – Fetteresso 1st Main Protection, 1st Main

			Protection Blocking and 2nd Main Protection Blocking

Table 3: Specific significant incidents

The operation of supergrid circuits with a single main protection is only permitted on a risk assessed basis. Where system or demand security would not be unacceptably compromised, the primary circuit is removed from service if there is no realistic prospect of the protection being restored within two hours. However, this does not consider the constraint costs that would arise when circuits are removed from service.

9 Detailed Examination of specific faults

In order to further highlight the improvements required, two specific faults were considered. The fault at Kaimes sub-station and the fire at Longannet Sub-Station were examined given the relevant severity and impact.

In 2019, an equipment failure resulted in the complete loss of communications at Kaimes sub-station for a period of 3 hours. The total loss of control and monitoring combined with significant protection depletion was a significant incident which, if unresolved, would have required the substation to be de-energised. Kaimes is a major sub-station located near Edinburgh, and hence the city would have been affected. The network visibility of 22 sub-stations was lost. In total, 52 protection services between 38 sites were also lost.

The root cause of the fault was found to be the complete failure of the site multiplexor, comprising the chassis and the cards. This is a single point of failure on the network. A second multiplexor failure has occurred at Strathaven sub-station which had a reduced impact on the network, though was still significant.

As outlined previously, the impact of loss of visibility and protection depletion was dependant on the network configurations at this time. However, customers were placed at risk for the duration of the repair. The repair time was relatively rapid, but this was due to co-incidental locations of staff, the spare(s) and the fault itself. Longer repair times and hence increased risk of issues on the network would be more likely in a repeat of this event. In addition, at different times of the year, such as during storms, the impact of the loss of visibility of the network, would be significantly different.

This failure outlined that the network topology used has a single failure capability with no capability for remote switching or larger options for routing around a failed site.

The 2018 Longannet fire was limited to the communications room. Significant damage was sustained to the equipment located within this building. As listed above, there were circuits switched out as this fault took longer to rectify. The exact impact of these circuits was assessed by SPT to be as follows

- LOAN – WFIE. <u>This would have resulted in the ESO having to take action to secure the network following the depletion of major system boundary B4.</u>
- MOSM SGT1. This reduced the security of supply of the local demand and the Mossmorran petrochemical plant.
- EERH SGT1. This resulted in an increased risk to the customers of SP Distribution. <u>There were 50,000 customers at single circuit risk</u>
- WIYH SGT2. This reduced the security of supply of the north of Glasgow and Argyll.

The impact of Longannet fault was mitigated by temporarily routing services across other comms paths resulting in a loss of diversity. However, this compounds the risk in that if there is a further issue, then there are correspondingly greater impacts as more and more services become affected for a fault.

The impact of Kaimes and Longannet was significant and it is believed necessary to develop revised design criteria to improve resilience and reduce the impact of any fault.

10 Improved Network Resilience Design Requirements

The assessment of Longannet and Kaimes faults, as examples, allowed for revised criteria to be selected for the required service levels. The following criteria have been proposed as the level of service required for the main interconnected 275kV and 400kV systems. This was compared to the National Grid standard and it was considered that there was strong correlation, validating the approach.

The network topology at Longannet was also studied to identify the impact of the fault and why the impact was so significant. This assessment focused on the integration of Longannet into the network, and if there could be improvements in the fibre routes that could be made to improve resilience. Appendix 1 outlines Longannet and the review of improvements that are proposed. This case study was used to base the RIIO-T2 improvements.

The assessment of the failures and the more detailed case studies identified the following design rules.

1) Any single failure of the telecoms network infrastructure should not result in any loss of 275/400kV circuits.

   a) Failure of equipment
   b) Failure of a fibre cable
   c) Failure of single power supply

2) The complete loss of a site should not result in the loss of any 275/400kV services that do not ingress or egress at that site.

   a. Failure of all equipment on site
   b. Failure of all fibre cables at a site
   c. Failure of all power supplies at site

The design principles below are proposed to be adopted in the proposed solution

1) Adoption of a dual and separate Strategic Telecoms network provisioning strategy, notionally named RED and BLACK

   a. Both networks separated by a minimum of 5m with Strategic Telecoms Network Point of Presence (PoP) in different rooms of the respective 400kV and or 275kV substation.
   b. RED was detailed to be the new network with BLACK in the existing network. Each site was to be considered in how to secure physical separation where possible.
   c. RED and BLACK to be vendor diverse if the risk versus cost impact warrant this approach

11 Optioneering

The following is a summary of the issues identified and the corresponding options considered for this paper.

There is equipment on the network that is End of Life and will be End of Support within RIIO-T2

There is an opportunity with new technology to improve performance under fault conditions to switch services

There is a need to improve resilience under fault conditions

The table below, Table 4, outlines the options considered.

	Option	Description of option
1	**Do nothing**: Maintain the existing telecoms network as is with no investment	This option is to avoid spend on this estate. This will result in the existing assets that are End of Support and End of Life not being replaced. In addition, there will be no additional fibre deployed
2	**Partial Upgrade work** Complete asset replacement for end of life equipment without rationalisation	Under this option, the existing assets will be deployed with the same 3 technology stacks where possible, but no new fibre will be deployed, and the resilient network will not be completed
3	**Equipment Rationalisation with no network improvements** This option rationalises the existing equipment into a single technology stack but does not implement fibre resilience works. However, this does require some fibre work to allow the new technology to switch correctly	Under this option, assets will be replaced into a single stack and associated fibre works deployed to ensure that the protection switching can be deployed
4	**Full implementation of Red/Black network** This option replaces the equipment, rationalises to a single network and implements the required fibre deployment for switching and implements fibre resilience improvements	Under this option, the technology stack is replaced, and the deployment of fibre designed for resilience. This also moves the services onto separate networks, denoted Red/Black to enable the resilience required and meet the design criteria proposed

Table 4: Options to be considered

12 Option assessment

The examination of the options has been completed as follows.

12.1 Option 1 - Do Nothing

Under this case, there is no further investment in the network. This will have the following impact:-

a. Active equipment will move to be out of support. This would result in any technical issues being significantly more difficult to resolve, and potentially require equipment replacement before a true failure.
b. Support for cyber security improvements such as Penetration improvements, threat assessments and upgrades will not be supported by the supplier. It is noted that there are Internet Protocol (IP) equipment installed which pose the greatest threat from a cyber threat surface.

c. The resilience improvements are not made, and the reliability of equipment will generally deteriorate with ageing
d. The design criteria are not achieved and the SPT network topology will remain different , and less resilient, to the other TOs in the UK.

12.2 Option 2 - Partial upgrade

The partial upgrade works will replace the existing 3-layer technology stack with newer equipment where this is possible. This has the following impact:

a. There will be an inefficient network as the 3 technologies will remain in place. It is more expensive as there are 3 pieces of equipment to purchase, install and manage.
b. There is an optimistic assumption that the PDH equipment, skills and labour will be able to be retained.
c. There is no improvement in the network as the existing performance will be generally retained. The issues around loss of resilience will remain.
d. While the equipment reliability will improve, given replacement, the improvements for protection switching will not be made and hence the performance of the network will retain the same weaknesses in this regard
e. The design criteria are not achieved and SPT will remain different, and less resilient, to the other TOs in the UK

12.3 Option 3 - Implement Single Technology Stack with no fibre resilience works

The single technology stack makes an improvement on the partial upgrade both from an efficiency viewpoint and also from a performance viewpoint. However, the following assessment is also made:-

This option does not remove sites from being a single point of failure (such as Longannet – Kincardine)

This option does not improve fibre resilience in the network. This still leaves customers at risk from the same issue identified at Longannet, namely

a. Failure of telecommunication equipment placing circuits of being switched out
b. The corresponding risk of the single supply/loss of customers from this loss of the circuit
c. The requirement for the ESO to utilise the Balancing Mechanism costs to mitigate the risk

The risks identified from Longannet were only at 275kV supply. The same failure on other sites could impact

a. The risks to Torness and Hunterston Power Stations with the corresponding security of supply risk
b. The impact on the 400kV power corridor and the power flows across major system boundaries
c. The performance of the network under a black start condition

These issues are considered further in Section 12.6.

12.4 Option 4 - Implement Red/Black and fibre resilience improvements

This option improves further on the Option in 12.3. This option deploys the single technology stack but also makes fibre network resilience improvements. This was considered as follows:-

a. The risk of third-party fibre damage is mitigated as alternative routes are available
b. There is no site that is at risk of a single point failure such as Kincardine (which terminates B4 boundary circuits), which relies on a single path from Longannet
c. There is increased security and resilience for more critical sites such as Torness and other 400kV sites which are critical for security of supply
d. Other sites, which pose risks to customers from the single circuit failure have increased resilience as a result.

12.5 Costs

Costs were developed for each of the options identified and these are detailed below in Table 5.

	Option 1	Option 2	Option 3	Option 4
RIIO-T2 275kV and 400kV Networks	Sweat Legacy Assets	Maintain three networks and refresh equipment	Single Technology Stack	RED and BLACK
	Maintain Network assets and wait until RIIO-T3 to replace	Replace EOL assets during RIIO-T2 but maintain current network topology and reutilise the same data links	RED and Black with current network topology and resiliency	RED and Black with improved Fibre and Site Resiliency
Cisco SDH		£2,045,000		
Nokia(Avara) PDH		£16,160,000		
IP Network Network		£7,680,000		
Collapse Networks into RED & BLACK and associated fibre works			£10,050,000	£10,050,000
Resilient Fibre deployment				£9,375,000
	£0	£25,885,000	£10,050,000	£19,425,000

Table 5: Pricing for the options

12.6 Option Discussion

The review of the corresponding risks and impact were assessed.

The Do-Nothing option, Option 1, was rejected given the increased risk of a lack of support to products, the impact of age-related defects and the need to retain skills for the support of this older technology which may become more difficult. This also posed substantial risks for cyber security, security of supply and customer risks.

Option 2, the replacement of the technology stacks with the same 3 levels, was clearly the most expensive option but fails to address the resilience improvements that are possible. It also fails to deploy the new technology that allows for operational improvements such as protection switching. Option 2 was rejected on that basis.

Option 3, the single technology stack but with no resilience improvements, has several attractions. However, this option does not address a number of key areas. This option leaves a number of sub-stations at single point failure. The case study from Longannet demonstrates the risks that this would pose. This includes large number of customers being at risk because of single circuit failure or increased constraint costs. The fault at Kaimes was also an example where the lack of resilience resulted in extensive impact to the visibility and operation of the network. While the impact was short-term, this was a result of specific circumstances and may not be repeated in a further event. Option 3 does not allow SPT to meet the wider design criteria as implemented by the other TOs, and leaves SPT as an outlier in the design of the Telecommunications network.

Option 4, the diverse RED/Back communications network, not only delivers the single technology stack of Option 3 but also delivers the resilience that the transmission network requires and aligns the practices of the TOs to ensure that a consistent approach is delivered to the interconnected and interdependent networks. This option mitigates single points of failure on the wider network and reduces the risk to customers. Each of the hardware failures that have been observed, and the significant issues experienced, would be mitigated by this option.

12.7 Summary Of options

The option assessment was as follows and listed below in Table 6:-

	Option	Consideration	Rejected/Proposed
1	**Do nothing**: Maintain the existing telecoms network as is with no investment	This option is to avoid spend on this estate. This will result in the existing assets that are End of Support and End of Life not being replaced. In addition, there will be no fibre deployed	This is rejected on the basis that the risks around EOL/EOS assets and lack of resilience are too great
2	**Partial Upgrade work** Complete asset replacement for end of life equipment without rationalisation	Under this option, the existing assets will be deployed with the same 3 technology stacks where possible, but no new fibre will be deployed, and the resilient network will not be completed	This is rejected because of cost
3	**Equipment Rationalisation with no network improvements** This option rationalises the existing equipment into a single technology stack but does not implement fibre resilience works. However, this does require some fibre work to allow the new technology to switch correctly	Under this option, assets will be replaced into a single stack and associated fibre works deployed to ensure that the protection switching can be deployed	This is rejected on the basis of:- The lack of resilience is inconsistent with other TOs The identified resilience leaves certain critical sites at risk of single point failures The resilience required protects customers as it reduces the probability of circuit removal due to communication failures It protects consumers from constraint costs due to communication failures
4	**Full implementation of Red/Black network** This option replaces the equipment, rationalises to a single network and implements the required fibre deployment for switching and implements fibre resilience improvements	Under this option, the technology stack is replaced, and the deployment of fibre designed for resilience. This also moves the services onto separate networks, denoted Red/Black to enable the resilience required and meet the design criteria proposed	**This is proposed as It is cost effective for equipment replacement** **It facilitates efficient switching** **It protects customers from loss of supply and consumers from constraint costs**

Table 6: Comparison of options

13 Delivery Strategy

An assessment was completed to ensure that the scope could be delivered within the required RIIO-T2 period while limiting the impact on the network. This assessment aimed to achieve the required levels of resilience, the following scope of work is proposed for the delivery of the proposed solution

1) Adoption of a dual and separate Strategic Telecoms network provisioning strategy, notionally RED and BLACK

   a) Both networks separated by a minimum of 5m with Strategic Telecoms Network Point of Presence (PoP) in different rooms of the respective 400kV and or 275kV S/S.
   b) RED and BLACK to be vendor diverse where practical and efficient to do so

2) Complete separation on site for 1st and 2nd Protection and dual route RTU comms (1st on RED, 2nd on BLACK)

3) All services to be telecoms Wide Area Network (WAN) switched (end to end service switching from ingress PoP to egress PoP)

4) All telecoms WAN bearers between sites required to be optical (to enable WAN switching)

5) All existing WAN fibres will require split termination with half of cores terminating in RED Optical Distribution Frame (ODF) and half of cores terminating in BLACK ODF at 275kv or 400kV sites

6) All existing WAN fibres that pass through <275kV sites to be 'glassed through' for all 275/400kV traffic

7) Any sites less than 275kV (132kV and below) do not require any additional separation

8) Any sites less than 275kV (132kV and below) will remain on the BLACK Strategic Telecoms Network

9) SPT-owned only fibre for all 275/400kV optical links

10) New SPT fibre to terminate at 275/400kV sites only

11) New intra-site Fibre Tie cables required between same network PoP where they do not already exist (BLACK 275 - BLACK 400), (RED 275 - RED 400)

12) No Fibre Tie interconnections between RED and BLACK PoP at any sites.

It is proposed to implement the mitigation as per the below outline plan.

2021 (RIIO-T2 Yr1)

1. Implement the required 400kV RED Network additional Fibre Links (2021)

a. Cockenzie 400kV to Torness 400kV (via Dunbar 132kV)

b. Windyhill 400kV to Neilston 400kV (via XF OPGW and Neilston 132kV)

2. Undertake the 400kV RED Network Site Separation Configurations at 22 sites

   a) COAL4, COCK4, CRYR4, DENN4, DEVM4, ECCL4, ELVA4, FALL4, GRNA4, HARK4, HUER4, HUNE4, KILS4, MOFF4, NEIL4, SMEA4, STHA4, TORN4, WISH4, WIYH4, SPHQ, KIRK GCC

3. Undertake the 400kV RED Network build at the 22 sites and transfer services from BLACK

2022-2023 (RIIO T2 Yr2 and Yr3)

4. Implement the required 275kV RED Network additional Fibre Links

a. East Kilbride 275kV to Busby 275kV

b. Coatbridge 275kV to Easterhouse 275kV

c. Giffnock 275kV to Dalmarnock 275kV

d. Drumchapel 275kV to Lambhill 275kV

e. Shrubhilll 275kV to Portobello 275kV

f. Shrubhill 275kV to Dewar Place 275kV

g. Longannet 275kV to Kincardine 275kV

h. ZC(s) OPGW to Kincardine 275kV (via XL OPGW)

i. Denny 400kV to Longannet 275kV (via ZC(S) existing OPGW)

j. Kilmarnock Town 275kV - Kilmarnock South 275kV

k. Wishaw 275kV - Ravenscraig 275kV (existing U/G)

l. Ravenscraig 275kV – Strathaven 275kV (via Motherwell 33kV)

5. Undertake the 275kV RED Network Site Separation Configurations at 48 sites

   a) AUCR2, AYR2, BONN2, BUSB2, CHAS1, CLYM2, CLYN2, COAT2, COCK2, COYL2, CURR2, DALL2, DALM2, DENN4, DEWP2, DRUM2, EERH2, EKIL2, EKIS2, ELVA2, GIFF2, GRMO2, INVR2, KAIM2, KILG2WFM, KILS2, KILT2, KINC2, LAMB2, LOAN PS, MAHI2, MOSM2, NEAR2, NECU2, NEIL2, POOB2, PORD2, RAVE2, SHRU2, SIGH2, SMEA4, STHA2, WFIE2, WGEO2, WHHO2, WHLE2WFM, WISH2, WIYH4

6. Undertake the 275kV Network RED Network build at the 48 sites and transfer services from BLACK Build

2024 (RIIO T2 Yr4)

7. Implement 400kV Network Black Network Refresh

   a. Collapse the multiple networks of MPLS-TP, ODN and PDH to single Optical Transport Network (vendor diverse where necessary from RED).

2025 (RIIO T2 Yr5)

8. Implement 275kV Network Black Network Refresh

   a. Collapse multiple networks of MPLS-TP, ODN and PDH to single Optical Transport Network

14 Environment & Sustainability

The SPT sustainability approach is to prioritise reuse, then refurbish and finally replace if there is no other option. Within this project the same ethos will apply. As the project is mainly focussed on increasing reliance and introducing diversity, there will be a large volume of new equipment installed. However, SPT will undertake assessments at each site to ensure that existing equipment is retained and used as part of the solution, or where made redundant but still operational, reused at another location.

15 Innovation

Innovation is a key component to deliver developments in all aspects of work. While the technology used in the project will be standard with a proven track record and the topology adopted in line with industry standards, SPT will look to use innovate ways of project delivery and installation to deliver the reliant telecoms network required.

16 Conclusion

The transmission network is critically dependent on highly resilient and available telecomms systems. Telecomms assets and systems have evolved due to rapid technology changes and relatively short asset lives. Service experience has highlighted a need to enhance the telecomms network to meet the required higher levels of resilience and availability to facilitate the energy system transition.

The proposed solution achieves this requirement and creates an aligned approach in the GB transmission system to deliver a resilient telecoms network for the future

- costs: £ 19.4 m
- Timing of investment: RIIO-ET2 period
- Declared outputs: N/A

17 Future Pathways – Net Zero

We have reviewed this project against the criteria set out within the business plan guidance and have assessed that it does not prevent achievement of our Net Zero plans or lead to stranded assets.

18 Outputs included in RIIO T1 Plans

None

Appendix 1 Detailed Assessment and Case Study for Longannet

19 Introduction

This case study considers the resilience of Longannet 275kV substation. This site was selected given a significant issue, but also as the site is a critical node within the electrical network. The assessment will consider the connectivity and consider the improvement options between sites so that improved resilience can be delivered.

Longannet has a number of connections to other sub-stations and the circuits have a direct influence on the capability of major system boundaries B4 and B5. It also carries a range of traffic which both traverses the site and terminates at the site. The table below, Table A1, outlines the telecommunications aspect:-

Description	Value
Number of site interconnections	PDH Network connects to the following sites • Townhill • Kincardine • Kirkintilloch • Edinburgh DCC • Knockhill • Westfield SDH connectivity to • Kincardine • Townhill Fibre connectivity to • Townhill • Kincardine • Dunfermline HDSL connectivity to • Kincardine Pilot Cable connectivity to • Kincardine
Number of services terminating at site	28 protection services IP Telephony IP Services SCADA Fault Recorders Network Management Services
Number of services traversing site	26 275kV Protection and inter-trip services

Table A1: List of services at Longannet Sub-station

In addition, while the main purpose of this document is the connectivity information, the equipment age and support status will also be reviewed as part of the wider asset management aspect.

20 Current Connectivity

The current connectivity at Longannet was assessed and a simplified version of this connectivity is shown below. Figure 1 shows the HDSL/Pilot cables (“Orange” links) and the Fibres (“Green” links) currently deployed and carrying operational traffic.

Connection to the centralised services at ScottishPower Headquarters (SPHQ) and Kirkintilloch Disaster Recovery Control Centre (KIRK GCC) is via Denny North and Bonnybridge sub stations

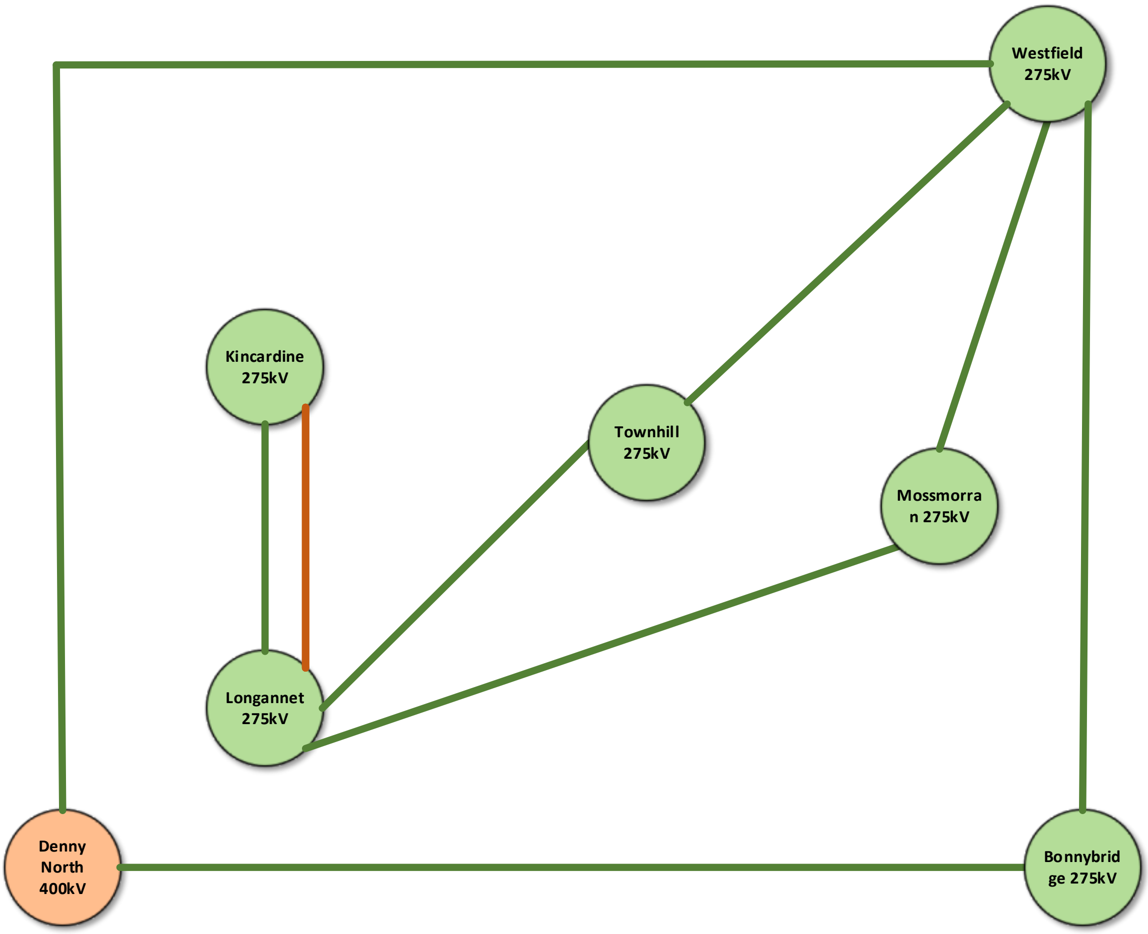

Figure 1: current telecoms network

A review of the architecture has identified the following aspects of weakness.

Longannet is a single point of failure for Kincardine, hence any issue at Longannet has a consequential impact to more than this single site.

Westfield is a single point of failure for the following sub-stations:

- Townhill
- Mossmorran
- Longannet
- Kincardine

There are therefore corresponding single point failures in the network. A revised architecture for the connectivity is required to mitigate this single point failure.

21 Design Review

As part of the design review for improvements, the following areas were highlighted as the base requirements.

1. A minimum of two fibre cables will connect to each 275kV substation which are diverse from each other which results in two distinct and resilient network paths back to the central network and localised network rings.

2. Optical fibres cables whether overhead or underground will have optical fibres designated for the telecoms room or associated room or for transiting the site to another sub-station

3. The fibre cables will be spliced externally to the buildings but within the overall site facility for security protection purposes.

4. There will be a minimum of two outdoor cabinets to cross-connect the fibres to ensure the integrity of diversity is maintained for entering the sub-station

The network was then considered for these design improvements.

22 Additional considerations

The assessment then reviewed the impact of wider RIIO-T2 improvements that are proposed. SP Transmission will deploy a 275kV digital substation at Longannet (scheme SPNLT2099) within RIIO-T2 which will utilise IEC 61850 Goose/MMS and will require network-based timing distribution of IEEE 1588 PTPv2 along with additional cyber-security capabilities.

SP Transmission will need to remove the SDH/PDH from the network within RIIO-T2 and as a result plan to consolidate the following services over the same fibre network:

- Key services:
  - SCADA
  - Tele-protection and inter-trip
- Additional Services
  - Measurement units for critical network parameters (including compliance with STCP 27-01)
  - Substation phones
  - Security services including CCTV and alarms
  - Network timing distribution

There are improvements that are now available for both the protection devices but also on the telecommunications technology. This will also have a benefit in the improvement in the protection and inter-trip service stability.

SPT have deployed a MPLS-TP network which allows for the protection service to be switched with no loss of service. This avoids the loss of protection service in the event of any changes in the telecommunications network, improving the network performance overall.

Within RIIO-T2, the telecommunications technology will only be deployed with similar hit-less switching technologies. However, this requires each service to have a primary and secondary path between the two end sites i.e. primary protection will have two paths and secondary protection will have two paths around the network.

23 Topology Improvements

23.1 Outline

The issues identified in the analysis of the network have been considered more widely across the network. The Longannet case study assumes the deployment of a central network core within RIIO-T2 utilising an all optical fibre network which will consolidate and ensure data traffic to and from Substations are connected to the centralised systems hosted in SPHQ and KIRK GCC. Figure 2 shows the connection of the sites into the wider network.

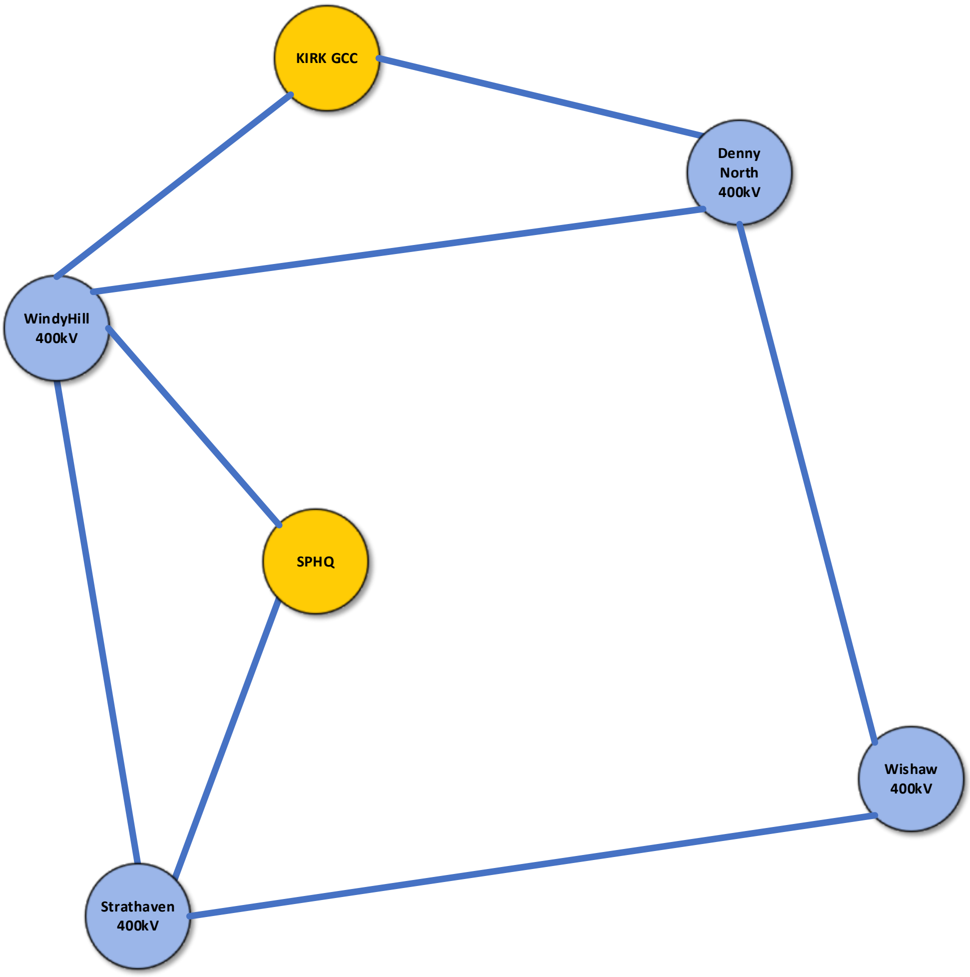

Figure 2: Central Core Network

23.2 Remove Single Point of Failure

The weakness of single point failure in the network was considered first. The improvement for this aspect commences with the installation of additional fibre cables to remove this weakness.

Figure 3 shows the new fibre links to be installed and Figure 4 shows the resulting network topology which requires the following implementation:

- Connecting pre-existing fibre links between Denny North and Longannet ("Green" dashed lines) utilising one of the following options:

  - Denny North to Tower ZCS062A to Longannet,
  - Denny North to Tower XD97 to DENN TEE to Tower TORW to Longannet
- New Fibre between Longannet and Kincardine ("Red" Dashed lines)

- Splicing the cable at Longannet to achieve the following:
  - Fibres connected between Denny North and Longannet
  - Fibres connected between Denny North and Kincardine
  - Fibres connected between Longannet and Kincardine (Pilot/HSDL migration)

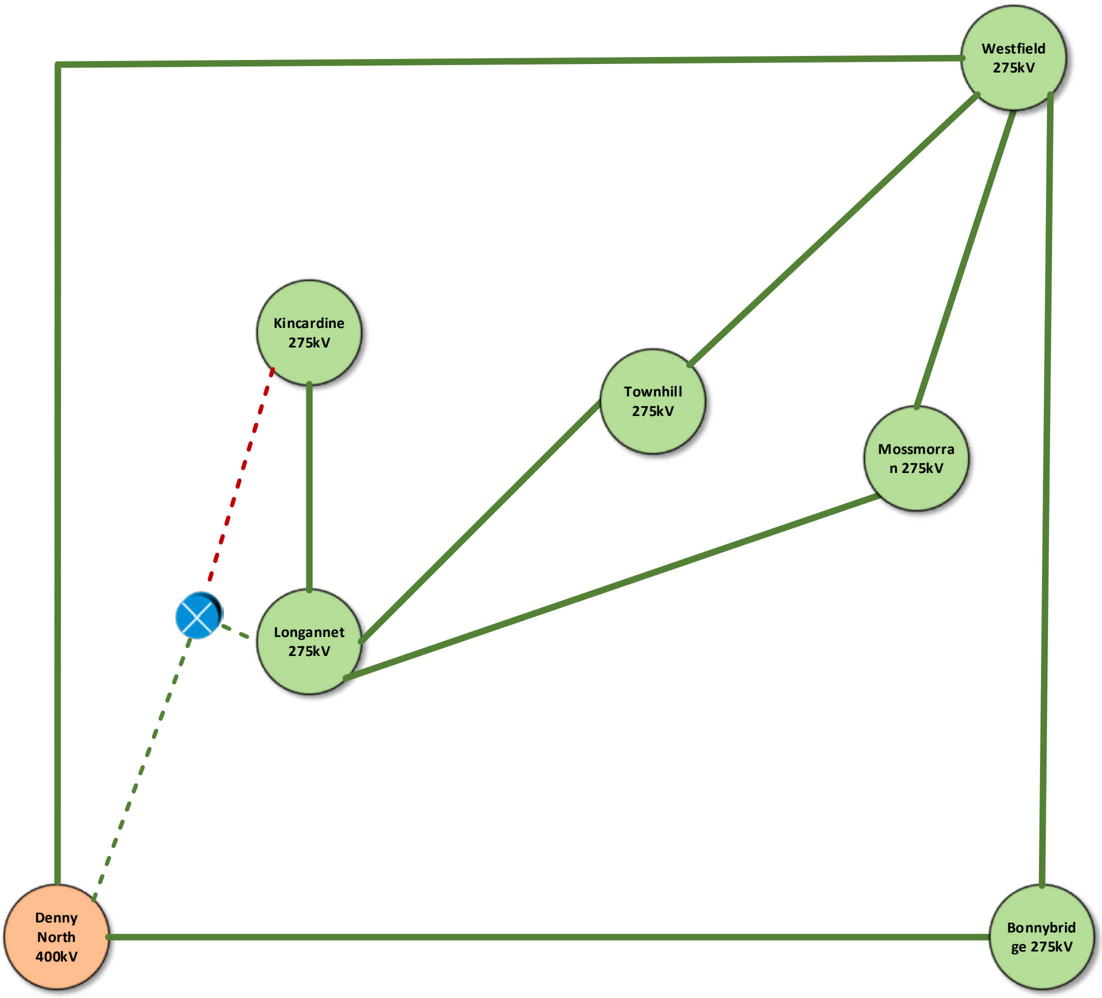

Figure 1: Additional Fibre Links

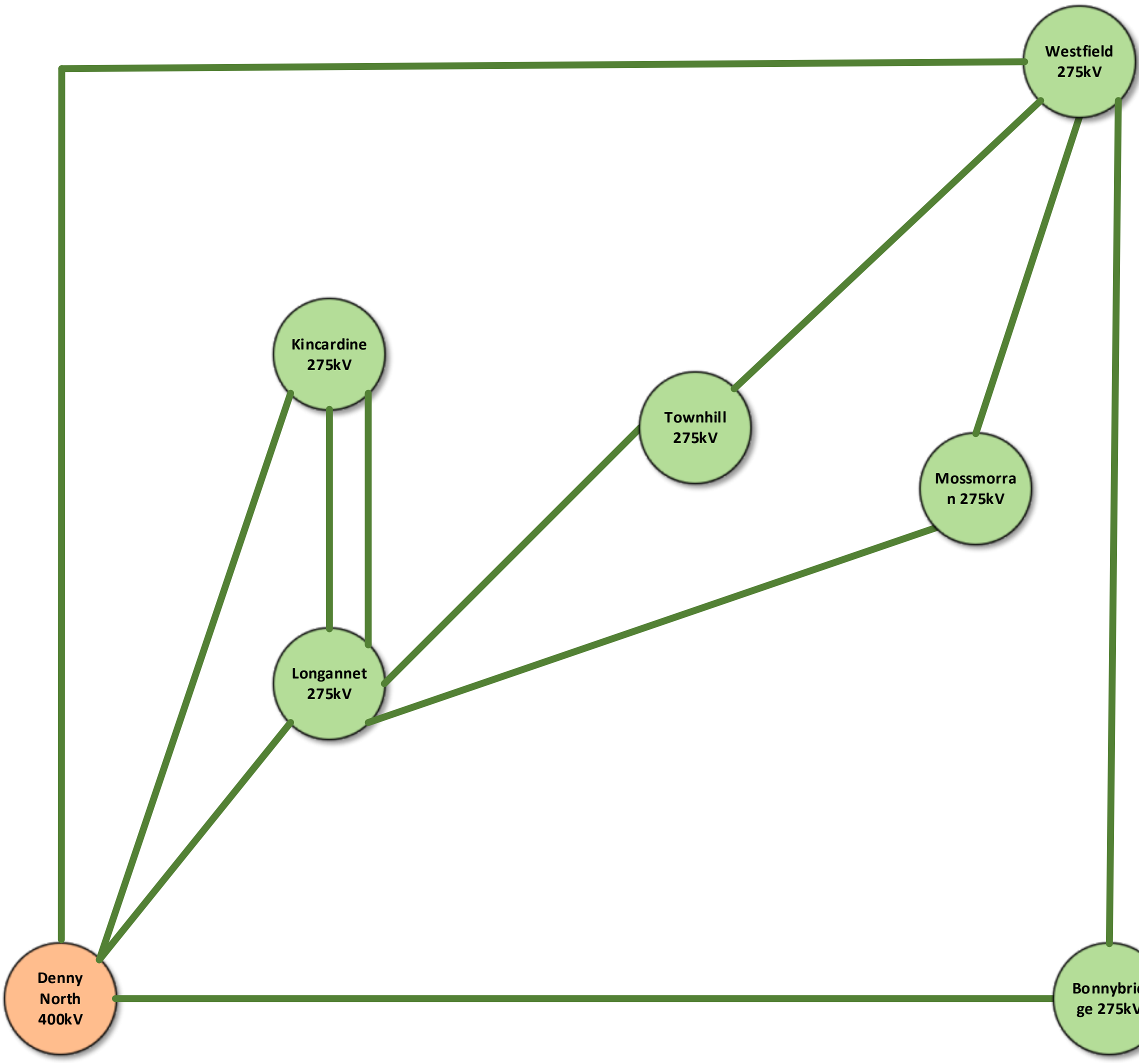

Figure 2: Resulting Fibre Network

23.3 Connection to Core Network

The next stage Figure 5 shows the connectivity to the central core via Denny North and Bonnybridge which provides the following:

- connectivity to the centralised services at SPHQ and KIRK GCC ("Yellow" circles)
- tele-protection and inter trip services to the following sub-stations:
  - 275kV Substation sites ("Green" circles)
  - 400kV substation sites ("Orange" Circles)

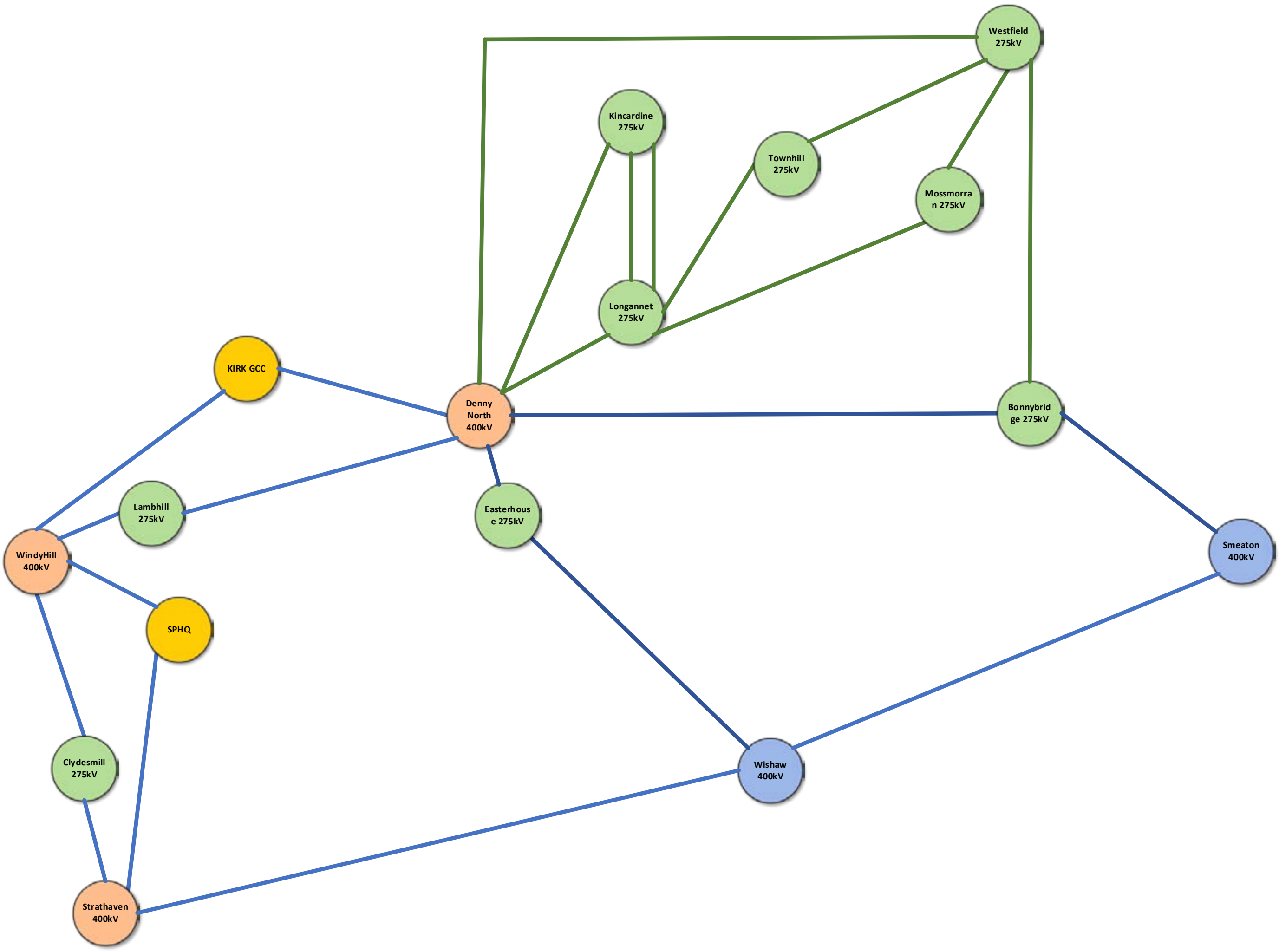

Figure 3: Longannet connection to Core Network

23.4 Diversification of services

This stage is final stage where the Longannet substation site is migrated to MPLS and equipment improvements are made:

- New Red Network equipment is installed
- Fibre cables spliced externally to the building and routed to control room and telecoms room
- Red Network equipment deployed, and Red enabled services migrated from the legacy networks including the primary tele protection and inter-trip services over to the fibre network
- Period of stability evaluation of the RED Network
- Refresh the Black Network equipment and move services over from the legacy network to the fibre network including the secondary tele protection and inter-trip services
- Period of stability and evaluation of the BLACK Network
- Remove old equipment in the telecoms room

24 Conclusion

This case study has reviewed the network topology at Longannet and has identified weaknesses in the existing design. It has then worked through improvements and identified the plan to ensure that the proposed improvements can be achieved.