

Kincardine North 400kV Substation Site Selection



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1 Introduction

This document is produced for the public consultation and its purpose is to explain SP Transmission plc (SPT) license duties, needs case and relevant methodology followed in developing the new Kincardine North 400kV substation and proposed location.

Electricity transmission is a licensable activity under section 4 of the 1989 Electricity Act ("the 1989 Act"). The 1989 Act places statutory duties and licence obligations on transmission licence holders.

SPT is licenced under section 6(1)(b) of the 1989 Act to transmit electricity. The licence is granted subject to certain standard and special conditions. Under section 9(2) of the 1989 Act, SPT as a transmission licensee is required to fulfil the following duties:

- To develop and maintain an efficient, co-ordinated and economical system for the transmission of electricity; and
- To facilitate competition in the supply and generation of electricity.

These statutory duties are reflected in SPT's transmission licence. In addition, and of relevance in the context of the Kincardine North Project, SPT has the following obligations pursuant to its licence conditions (LCs):

- to at all times have in force a System Operator-Transmission Owner Code (STC) which, amongst other things, provides for the co-ordination of the planning of the transmission system (LC B12);
- to at all times plan and develop the transmission system in accordance with the National Electricity Transmission System Security and Quality of Supply Standard (LC D3);
- to make available those parts of the transmission system which are intended for the purposes of conveying, or affecting the flow of, electricity so that such parts are capable of doing so and are fit for those purposes (LC D2); and
- to offer to enter into an agreement with the system operator on notification of receipt of an application for connection or for modification to an existing connection (LC D4A).

Section 38 and Schedule 9 of the 1989 Act also impose duties on SPT when formulating any relevant proposals. In response to statutory and licence obligations upon it, SPT therefore requires to ensure that the transmission system is developed and maintained in an economic, co-ordinated and efficient manner, in the interests of existing and future electricity consumers, balancing technical, economic and environmental factors. Efficient in this context should be understood to mean a project being developed, procured and delivered at least cost to consumers.

The construction of the proposed Kincardine North 400kV Substation, and associated works, is vital in facilitating the economic integration of renewable generation and reaching legislated net zero targets. In the following sections the background and options considered are described and the justification for the proposed Kincardine North 400kV Substation is presented.



2 The need for the scheme

In June 2019, the United Kingdom (UK) parliament passed legislation introducing a binding target to reach net zero greenhouse gas emissions by 2050. In Scotland, the Scottish Parliament has committed Scotland to becoming a net zero society by 2045. The timely connection of low carbon generation, such as onshore and offshore wind, will play a vital role in reaching these legislated net zero targets.

The UK Government announced in October 2020 its commitment to make the UK a world leader in green energy and boosted the UK Government's previous 30GW target for offshore wind to 40GW by 2030. The Scottish Government ambition is 11GW of offshore wind in Scotland by 2030. Further commitments, by the UK Government in October 2021, to decarbonise the power system by 2035, as well as British Energy Security Strategy¹ published April 2022 (which raises the UK Government ambition to 50GW of offshore wind by 2030), further support the requirement for investment in the existing electricity transmission system to enable the timely connection and integration of the required renewable generation sources.

The electricity transmission system in Great Britain is therefore going through a transformational change as we move towards a net zero emissions society. Traditional large fossil fuel power stations are being replaced by a large number of renewable generating stations such as onshore and offshore wind farms.

The existing electricity transmission system was designed and built to take power from those traditional large power stations, often coal fuelled (such as Kincardine and Longannet) and take it to demand centres throughout the central belt of Scotland and beyond. However, renewable generators are now connecting to the system. These generators are located in areas where there is very little demand, such as in the north of Scotland. To allow this renewable electricity to be carried from the north to the large demand centers throughout Great Britain, there is a need for modernisation and reinforcement of the electricity transmission system across Scotland and Great Britain.

The SPT network in central and south Scotland is crucial to the delivery of the UK and Scottish Government renewable energy and decarbonisation objectives, due to its location in an area of outstanding renewable resource and its position between the SSEN Transmission area (in the north of Scotland) and the National Grid Electricity Transmission (NGET) area in England and Wales. SPT has a unique role in connecting renewable generation and the bulk transfer of renewable energy from its area and from the north of Scotland. SPT's activities therefore benefit stakeholders throughout Great Britain.

The Network Options Assessment (NOA)² is carried out every year to determine what, if any, additional capacity will be required and economically justified to ensure current and future generation can flow from where it is produced to where it is needed. This assessment has identified that the construction of a 400kV Substation in the Kincardine area, and the associated uprating of several circuits on the overhead line network that currently run at 275kV to 400kV, is required. This project will enhance the transmission infrastructure in the central belt of Scotland and is critical to enabling Scotland and the UK achieve its net zero carbon emissions targets.

¹ <u>British energy security strategy - GOV.UK (www.gov.uk)</u>

² The Network Options Assessment (NOA) is carried out annually by National Grid Electricity System Operator (NGESO) and evaluates proposed system reinforcement projects against future generation and demand scenarios to determine what transmission system reinforcement is required and when this should take place.



A Holistic Network Design (HND) assessment has recently been carried out by National Grid Electricity System Operator (NGESO). This considered the connection of recently contracted offshore windfarms around the Scottish coast and how the power that they generate will be transported to the load centers. The Kincardine North project was identified as a key enabling project to facilitate future network upgrades and ensure that power flows efficiently through the system. Further detail of this assessment can be found on the National Grid ESO website³.

3 Scheme Description

The proposed scheme will consist of several components, key to which is the establishment of a new 400kV substation (referred to here as 'Kincardine North 400kV Substation') and the reinforcement of existing transmission overhead lines and substations.

Figure 1 shows the geography of the transmission network in the Kincardine area. Note that dotted blue lines denote steel lattice overhead line infrastructure.

The components of the proposed scheme include:

- Construction of the proposed Kincardine North 400kV Substation.
- Construction of two new circuits between the proposed Kincardine North 400kV Substation and the existing Kincardine 275kV Substation (it is expected that these connections will be achieved via underground cables).
- Uprating of the existing 275kV overhead line (known as XL Route⁴) between the proposed new Kincardine North 400kV Substation and the SSEN Transmission boundary - this uprating will increase the capacity and operating voltage of the overhead line (from 275kV to 400kV).
- Uprating of the existing 275kV overhead line (known as ZC(N) Route) between the proposed Kincardine North 400kV Substation and Denny North 400kV Substation. This uprating will increase the capacity and operating voltage of the overhead line (from 275kV to 400kV).
- Uprating of the existing 275kV overhead line (known as ZC(S) Route) on one side between the proposed Kincardine North 400kV Substation and Denny North 400kV Substation. This uprating will increase the capacity and operating voltage of the overhead line (from 275kV to 400kV).
- Turning in the existing XL, ZC(N) and ZC(S) overhead lines to the proposed Kincardine North 400kV Substation.
- The reconfiguration of the existing overhead lines at the proposed Kincardine North 400kV Substation, joining one side of ZC(S) Route and one side of XL Route to provide a 275kV overhead line between Kincardine 275kV Substation and Easterhouse 275kV Substation.

³ Link: <u>The Pathway to 2030 Holistic Network Design | National Grid ESO</u>

⁴ Within SPT, the naming convention for transmission overhead lines is for overhead line routes to be identified by a unique letter or combination of letters. Unique identification of individual towers on the SPT system is therefore achieved by adding a sequential number to the route designator, e.g. XL005 being the fifth tower on XL Route.





Figure 1: Existing SPT network around Kincardine area



4 Proposed Kincardine North 400kV Substation on the southwest of the Kilbagie Crossing (Preferred location)

The proposed Kincardine North 400kV Substation will be a key enabler to allow the connection of renewable generation throughout Scotland and provide additional capacity to transfer power from the north of Scotland to the south.

In addition, the existing Longannet 275kV Substation is reaching the end of its operational life and requires intervention, including replacement of the substation, within our current price control period which ends in 2026. The proposed Kincardine North 400kV Substation will facilitate the decommissioning of the existing Longannet 275kV substation and the establishment of a new node in the system that will provide much needed additional capacity.

Under its transmission licence, SPT has a duty to develop and maintain an efficient, co-ordinated and economical system of electricity transmission. In recognition of the project drivers and its statutory duties and licence obligations, SPT is planning to develop the scheme to establish the proposed Kincardine North 400kV Substation, close to where the existing 275kV overhead line circuits meet (known as the 'Kilbagie Crossing').

Following a high level technical and environmental review of the potential sites the most appropriate location to construct the substation around the Kilbagie Crossing is to the southwest, as outlined in Figure 2. An indicative electrical layout of the proposed new substation and the proposed diversions of the existing overhead line infrastructure is shown in Figure 3.

This option would require overhead line diversions on ZC(N), ZC(S) and XL Routes to turn the existing circuits into the new substation. As all of these routes are in close proximity to this location, the length of the required diversions would be relatively short.

This proposal requires a new 275kV circuit between Kincardine North 400kV and Kincardine 275kV Substations to deliver the required connectivity. It is expected that an underground cable connection will be required for this circuit. An overhead line connection is not considered to be appropriate due to the close proximity of the Ramsar site (the pink crossed area) and Ancient Woodland (the solid pink area) shown in Figure 4, Scheduled Monuments (<u>Tulliallan Castle</u>) and Garden and Designed Landscapes (<u>Tulliallan</u>) (the solid green area) shown in Figure 5, and the proposed Battery Energy Storage System (BESS) and synchronous condenser developments in the area.

This location is considered to provide the most economic, efficient, and co-ordinated solution for the construction of Kincardine North 400kV Substation. It requires the least amount of new overhead lines and underground cables to be constructed, and, from a desktop assessment, avoids several environmental challenges that some of the alternative locations are subject to, including having a reduced risk of flooding.

This is therefore considered to be the preferred location for the proposed Kincardine North 400kV Substation as it is efficient in terms of ensuring the maximum utilisation of the existing infrastructure, requires the least amount of new infrastructure to be constructed, and is economical in terms of providing the lowest cost solution for existing and future consumers.

Assessments of alternative options including areas around the Kilbagie Crossing are presented in subsequent sections of this document.





Figure 2: Proposed Kincardine North 400kV substation location on the southwest of the Kilbagie Crossing (preferred solution)





Figure 3: Electrical layout of the proposed new substation and surrounding area



Figure 4: Ramsar and Ancient Woodland around the location on the southwest of the Kilbagie Crossing





Figure 5: Scheduled Monuments and Garden & Designed Landscapes



5 Alternative Options

Several potential options were identified and evaluated by SPT when considering the best location for the new substation, including siting the new substation at various existing SPT sites. The locations considered are as follows, with further details provided in this paper:

- Do Nothing
- Paper Mill site near to the Kilbagie Crossing
- Northeast of the Kilbagie Crossing
- Southeast of the Kilbagie Crossing at Windyhill Farm
- West of the A876
- Around the existing Longannet substation
- Around the existing Kincardine substation
- Hybrid location across both the Paper Mill site and the northern section of the field to the west of the Kilbagie Crossing

5.1 Do nothing

A 'Do Nothing' option is not credible in relation to this project and would be inconsistent with SPT's various statutory duties and licence obligations. Timely progression of the uprating of transfer capability through the SPT system is crucial to ensure continued security and reliability of supply, enabling growth in renewable generation and supporting the transition to net zero in the most economical way.



5.2 Construct a new substation at the former Paper Mill site near to the Kilbagie Crossing

An alternative at the former Paper Mill site on the northwest of the Kilbagie Crossing was considered as a possible location for the new 400kV Substation. A potential site layout is shown in Figure 6.

This location is in very close proximity to two Listed Buildings as shown in Figure 7 – <u>Kilbagie Mill House</u> (<u>Category C</u>) and <u>Kilbagie House and Garden Walls (Category B</u>). The location of these listed buildings would make it challenging to develop Kincardine North 400kV Substation in this location due to the likely potential effects on the setting of the Listed Buildings.

It is expected that both ZC(N) and ZC(S) Routes could be turned in to this location in a similar way to the preferred location. However, it is more challenging to turn XL Route into this location due to the increased distance between this location and the existing towers on XL Route. On the circuits to Kincardine 275kV Substation utilising XL Route to the south, it is expected that a diversion including three new towers would be required to make the connection to the section of XL Route to the south. On the circuits north to the SSEN Transmission area, it is expected that a diversion across the railway and A977 including two new towers would be required to make the connection to XL Route. This diversion to the north could connect to the existing XL Route at the existing terminal tower XL007. This option would allow for the removal of the undercrossing sections of XL Route at the Kilbagie Crossing, where the circuits on XL Route pass underneath both ZC(N) and ZC(S) Routes.

The new circuits from Kincardine North 400kV Substation to Kincardine 275kV Substation would be achieved through underground cables, for the same reasons as for the preferred location detailed in Section 4. The main difference between the former Paper Mill site and the preferred site is the longer route length of these underground cable circuits.

The cost estimate for the substation in this location is considerably more than the preferred location. There are some savings made associated with the reduced requirements to construct both a construction haul road and permanent access road to the site, based on the assumption that the existing access from the A977 to the former Paper Mill site could be used for this purpose. However, these savings are more than offset by the costs associated with the additional underground cable lengths that are required on the new circuits from Kincardine North to Kincardine.





Figure 6: Substation at the Paper Mill site



Figure 7: Listed buildings near Paper Mill site



5.3 Construct a new substation on the northeast of the Kilbagie Crossing

Another alternative to the northeast of the Kilbagie Crossing was considered as a possible location for the new 400kV Substation. A potential site layout is shown in Figure 8. Assuming the site layout and size is the same as the preferred location, the substation in this location would require the loss of the native woodland in the area, shown in Figure 9 as the orange area. This is unacceptable in principle in terms of national planning policy and there is another viable alternative site. From a desktop assessment, this location also looks to be close to properties around Tulliallan Farm, which is likely to be a landscape and visual concern.

It is expected that both ZC(N), ZC(S) and XL Routes could be turned in to this location in a similar way to the preferred location.

The new circuits from Kincardine North to Kincardine would be achieved through underground cables, for the same reasons as for the preferred location detailed in Section 4. The main difference between this location and the preferred site is the longer route length of these underground cable circuits.

The cost estimate for the substation in this location is considerably more than the preferred location. The increase in costs is primarily due to the additional underground cable lengths that would be required for the new circuits from Kincardine North to Kincardine.



Figure 8: Substation location on the northeast of the Kilbagie Crossing





Figure 9: Native woodland at the northeast of the Kilbagie Crossing



5.4 Construct a new substation on the southeast of the Kilbagie Crossing at Windyhill Farm

An alternative on the southeast of the Kilbagie Crossing was considered as a possible location for the new 400kV Substation. A potential site layout is shown in Figure 10. The proposed location is around Windyhill Farm in the area, currently occupied by a wind turbine. From a desktop assessment, this location is higher in the landscape, which is likely to be a landscape and visual concern. This location was deemed to be the most feasible option on the southeast of the Kilbagie Crossing to minimise impacts on Tulliallan Golf Course, Tulliallan Police College, Garden and Designed Landscapes (Tulliallan), shown in Figure 5, and Ancient Woodland, shown in pink in Figure 11.

Assuming the site layout and size is the same as the preferred location, there is enough space in this location assuming that the wind turbine can be removed. It is expected that both ZC(N) and ZC(S) Routes could be turned in to this location in a similar way to the preferred location.

The major challenge with this location is the connection back to XL Routes for the circuits north and south. It is expected that these connections would need to be made via underground cable due to the proximity of Tulliallan Golf Course, Tulliallan Police College, Garden and Designed Landscapes (Tulliallan), shown in Figure 5, Native Woodland, shown in Figure 9, and Ancient Woodland, shown in Figure 11. These constraints would make it extremely challenging to route two new double circuit steel lattice tower routes to this location to facilitate the required connectivity. It is expected that these underground cable circuits would be routed to the existing terminal towers XL006 and XL007 on either side of the Kilbagie Crossing. Due to the number of underground cables per phase required for the connections, fenced cable termination compounds would be required adjacent to the existing terminal towers at the end of the underground cable sections. This option would allow for the removal of the undercrossing sections of XL Route at the Kilbagie Crossing, where the circuits on XL Route pass underneath both ZC(N) and ZC(S) Routes.

The new circuits from Kincardine North 400kV Substation to Kincardine 275kV Substation would also be achieved through underground cables, which is the same assumption that has been made for the preferred location for the same reasons detailed in Section 4. The main difference between this location and the preferred site is the longer route length of these underground cable circuits.

The cost estimate to establish the new substation in this location is considerably more than the preferred location. There are some savings made associated with the reduced requirements to construct both a construction haul road and permanent access road to the site, based on the assumption that the existing access to Windyhill Farm could be used for this purpose. However, these savings are more than offset by the costs associated with the additional circuits that are required to both XL006 and XL007, and the additional underground cable lengths that are required on the new circuits from Kincardine North to Kincardine.

It is likely that there will be additional challenges associated with this site due to the topography of the ground in this area. From a desktop assessment, it appears to be less flat that the preferred location and so is likely to require more complex and expensive earthworks to construct the substation platform. This has not been accounted for at this time and would lead to additional costs being incurred. The costs associated have not been quantified at this stage as this location can be ruled out on economic grounds without taking this into consideration.





Figure 10: Substation location on the southeast of the Kilbagie Crossing at Windyhill Farm



Figure 11: Ancient Woodland on the southeast of the Kilbagie Crossing



5.5 Construct a new substation west of the A876

An alternative on the west of the A876 was considered as a possible location for the new 400kV Substation. A potential site layout is shown in Figure 12. Assuming the site layout and size is the same as the preferred location, there is space for the substation to be located between ZC(N)022 and ZC(S)022, the A876 and Craighton Farm.

It is expected that both ZC(N) and ZC(S) Routes could be turned in to this location in a similar way to the preferred location.

It is more challenging to turn XL Route into this location due to the increased distance between this location and the existing towers on XL Route. On the circuits north to SSEN Transmission's area, it is expected that a diversion including three new towers would be required to make the connection to the section of XL Route to the north. On the circuits to Kincardine substation utilising XL Route to the south, it is expected that a new terminal tower around XL003 would be required, with underground cable circuits between Kincardine North substation and this new terminal tower. Due to the number of underground cables per phase required for the connection, fenced cable termination compounds would be required adjacent to the new terminal tower at the end of the underground cable sections. It is expected that an underground cable connection would be required for the same reasons detailed in Section 4. Furthermore, as with the preferred option detailed in Section 4, it is anticipated that the new circuits from Kincardine North substation to Kincardine substation would also be achieved through underground cables.

The cost estimate for the substation in this location is considerably more than the preferred location. There are some savings associated with the reduced requirements to construct both a construction haul road and permanent access road to the site, based on the assumption that the existing access from the A876 and Carse Road could be used for this purpose. However, this saving is more than offset by the costs associated with the additional underground cable circuits that are required, along with the associated fenced cable termination compounds.

It is likely that there will be additional challenges associated with this site due to the diversion of the Canal Burn and flood risk mitigation due to the potential issues associated with coastal and surface water flooding as indicated in publicly available information in the SEPA web site⁵. Neither of these aspects have been allowed for in the cost estimate at this time; however, they would both lead to additional costs being incurred. The costs associated with these works have not been quantified at this stage as this location can be ruled out on economic grounds without taking these points into consideration.

⁵ Link: Flood Maps | SEPA - Flood Maps | SEPA





Figure 12: Site on the west of the A876



5.6 Construct a new substation in the Longannet Area

An alternative location around the Longannet area was considered for the new 400kV substation. This option is different to the others that have been assessed so far as, while the configuration of the substation would be similar to the other options, there would need to be a reconfiguration of the overhead lines around the Kilbagie Crossing to achieve the required circuit configuration.

As with all the substation locations around the Kilbagie Crossing considered from Section 5.2 to 5.5, a new 400kV substation around Longannet would require two 275kV underground cable circuits from the new substation around Longannet to the existing Kincardine substation. The underground cables from around Longannet would be considerably longer than the equivalent underground cables to any of the other locations, and so the costs associated with these underground cable circuits would also be considerably higher.

5.6.1 Substation location at Longannet

Two different locations around Longannet were considered as potential locations for the new 400kV substation, shown below in Figure 13. Records indicate that there is a gas pipeline crossing both the western and eastern areas, indicated in Figure 14 as the orange line, that used to connect to Longannet Power Station. Works to realign this gas pipeline would need to be considered for either option, which would add to project costs. The western option was deemed to be the most appropriate location to construct a new 400kV substation as it removes some of the risks associated with flooding. The western area has a risk of some surface water flooding; however, it is less than the eastern area which also has significantly greater risk of coastal flooding as indicated by publicly available information in the SEPA5 web site. The greater flood mitigation works that would be required for the eastern option when compared to the western option would result in this location being a more expensive area to construct a new 400kV substation. The eastern option would also potentially require the removal of Ancient Woodland (the solid pink area), shown in Figure 15. Based on this assessment, the western option was deemed to be the most appropriate of these two locations to construct a new 400kV substation around Longannet.





Figure 13: Potential substation locations around Longannet



Figure 14: Gas pipeline crossing the area north of Longannet





Figure 15: Ancient Woodland around Longannet



5.6.2 Circuit reconfiguration

Three different options of circuit configurations around the Kilbagie Crossing were considered as part of the assessment of constructing the new 400kV substation in the Longannet area. An assessment of the overhead line and underground cable works that would be required to achieve these configurations was carried out, with the results shown as Options 1 to 3 in Figures 16 to 18 respectively.

Based on this assessment, Option 2 was not taken forward to a detailed costing exercise as it requires an underground cable section, with the associated fenced cable termination compounds, to achieve the desired configuration. Given that both Option 1 and Option 3 do not require an underground cable section, Option 2 is known to be a significantly more expensive solution and so was ruled out on economic grounds.

Option 1 and Option 3 are similar in that they both require some new towers to be built both on-line and off-line, and both allow for some short sections of the existing overhead line routes to be decommissioned and removed. Both options would require new towers to be built in a similar area and so would have to work around the same environmental challenges.

For Option 1, a more direct new build overhead line route than the one shown could be established between towers XL003 and ZC(S)022; however, there are challenges associated with the Ramsar site, as well as the proposed BESS and synchronous condenser developments in the area. As a result, the alignment shown in Figure 16 has been considered at this stage.

5.6.3 Cost commentary

Given all the considerations detailed above, the cost estimate for the new 400kV substation around Longannet is considerably more, based on Option 1 or Option 3, than the preferred location. The main reason for this difference is the considerably longer underground cable circuits required from the location around Longannet to Kincardine substation.

There will be additional challenges associated with these options due to the requirement to uprate the existing YG Route between Longannet and Kincardine substations to 400kV operation. A high-level assessment of these works has identified issues that would need to be overcome; however, it is thought that this uprating is possible with some tower modifications. The costs associated with these modifications have not been allowed for in the cost estimate at this time; however, they would lead to additional costs being incurred. The costs associated with these works have not been quantified at this stage as the Longannet options can be ruled out on economic grounds without taking these points into consideration.





Figure 16: Option 1 – XL Route turned onto ZC(N) on both sides



Figure 17: Option 2 – XL Route turned onto ZC(N) northern side only

Figure 18: Option 3 – XL Route turned onto ZC(S) southern side only

5.7 Construct a new substation at Kincardine

Consideration was given to the construction of a new 400kV substation at the site of the existing Kincardine 275kV substation. The new 275kV substation has recently been rebuilt as an indoor gasinsulated switchgear (GIS) substation with extensive flood protection measures. The significant challenges in terms of substation, overhead line and cabling works are described below.

5.7.1 Substation works

A new 400kV substation at Kincardine would require similar flood protection measures, which would result in extensive civil works being carried out to raise items of plant, such as the two new supergrid autotransformers and 400kV GIS building, above the flood level.

Two options were considered for ensuring that the two new supergrid autotransformers would be installed above the flood level:

- Raising the substation platform level above the flood level by importing material
- Installing all equipment on structures to raise them above the flood level

The first of these options was deemed to be impractical due to the cost, programme and environmental impact associated with building up the substation platform. The typical maximum gradient on roads for transformer delivery is 1:12, meaning that an access road of around 60m would be required to get to the correct level. Due to the ground conditions, this is likely to settle over time on the existing soil, and so piles would potentially be required to prevent differential settlement. The amount of space required to get a suitably graded access road up to the required level would be extremely challenging.

The second option was also deemed to be impractical due to the cost and programme implications. Alternative options for delivering the two new supergrid autotransformers to site to be installed on structures above the flood level were considered. These included the use of a large mobile gantry or large capacity crane. From an initial assessment it was not clear whether there would be sufficient space available at site to use either of these options given the substation layout and other works that would be required. This would also have significant cost and programme implications as these methods of transformer delivery would require more expensive equipment and more time available on site due to the complexities associated with installing the transformers at height. The equipment required for these delivery methods are not easily available and long-term bookings are required.

Due to the size of the new substation, the plant required, and the associated flood protection measures, this option could not be accommodated within the land available at the Kincardine site and so it was ruled out on the grounds of feasibility and cost.

5.7.2 Overhead line and underground cable works

To provide the required circuit configuration for a solution at Kincardine, two new double circuit connections would require to be constructed initially to connect the new substation at Kincardine to the existing ZC(N) and ZC(S) Routes in the Kilbagie area, with another two new double circuit connections potentially required in future to connect to the other side of these routes. It is anticipated that this would be achieved through underground cables, which is the same assumption as has been made for the preferred location for the same reasons detailed in Section 4.

Each of these circuits would require at least two underground cables per phase to deliver the required capacity and would also require fenced cable termination compounds adjacent to new terminal towers on these routes at the end of the underground cable sections.

Given the size of underground cables at 275kV and 400kV, and the spacing requirements between circuits, it would be extremely challenging to install these circuits as it would involve a minimum of 48 single core 275kV or 400kV underground cables to connect from the existing overhead line routes to the new substation at Kincardine.

Hence this option was ruled out on the grounds of feasibility and cost prior to a detailed cost estimate being produced based on the scope of work of this option in comparison to the others, and the relative costs of underground cables in comparison to overhead lines.

5.8 Construct a new substation between the former Paper Mill site and the field to the west of the Kilbagie Crossing

An alternative location to the north of the preferred location for Kincardine North 400kV Substation was considered, this is sited across both the former Paper Mill site and the field to the west of the Kilbagie Crossing. A desktop assessment has been carried out on the potential site layout as shown in Figure 19.

Figure 19: Alternative substation location at the Paper Mill and Field site

The preferred location requires two new circuits between Kincardine North 400kV and Kincardine 275kV Substation, it is expected that an underground cable connection will be required for these circuits. An overhead line connection is not considered to be appropriate due to the close proximity of the Ramsar site (the pink crossed area) and Ancient Woodland (the solid pink area) shown in Figure 20, Scheduled Monuments (<u>Tulliallan Castle</u>) and Garden and Designed Landscapes (<u>Tulliallan</u>) (the solid green area) shown in Figure 21, and the proposed Battery Energy Storage System (BESS) and synchronous condenser developments in the area.

Figure 20: Ramsar and Ancient Woodland around the location on the southwest of the Kilbagie Crossing

Figure 21: Scheduled Monuments and Garden & Designed Landscapes

This location is in close proximity to two Listed Buildings as shown in Figure 22 – Kilbagie Mill House (Category C) and Kilbagie House and Garden Walls (Category B). The location of these buildings

would make it challenging to develop Kincardine North 400kV Substation in this location due to the likely potential effects on the setting of the Listed Buildings.

Figure 22: Listed buildings near Paper Mill site

A water course and pond area are located in the middle of the alternative site that would require to be either diverted through a culvert or diverted from its current path, these are shown in figure 23 below.

Figure 23: Pond and water course at alternative site location

Safe construction of the substation at the alternative location would require the ZC(N) and ZC(S) routes to be switched out of service or diverted as it is located under those routes. Due to the constraints that would be caused on the Transmission System it is extremely unlikely that outages would be granted by the Electricity System Operator to safely construct the platform. This would make the diversion of the ZC(N), ZC(S) and XL overhead line routes necessary, the latter to clear space to allow the former to be moved. As a result, it is expected the diversions to clear the area where the Kincardine North 400kV Substation would be constructed would be extensive. They would require fourteen new towers and approximately 36km of overhead line conductor to be installed for the construction period. It is expected that the diversion of the XL route would cross the railway line and an area of woodland to the west of the railway line. The latter would result in the loss of that woodland, which is unacceptable in principle in terms of national planning policy. Both ZC(S) and ZC(N) would be diverted further into the field to the south of the alternative site and would require a crossing of the A876 Clackmannanshire Bridge Road in two places. The potential overhead line diversions are shown in Figure 24.

The final overhead line configuration would be likely to require a further 10 new towers and approximately 12km of overhead line conductor to be installed.

Figure 24: Potential overhead line route diversions

The cost estimate for the substation in this location is considerably more than the preferred location. The increase in costs is primarily due to the extensive overhead line diversions and the additional underground cable lengths that would be required for the new circuits from Kincardine North to Kincardine.

6 Conclusions

The establishment of the proposed Kincardine North 400kV Substation is key to facilitating the economic integration of this new renewable generation in the surrounding area. The timely connection of low carbon generation, such as onshore and offshore wind, will play a vital role in reaching legislated net zero targets.

6.1 SPT Licence Duties

As the holder of a transmission licence, SPT has a statutory duty to develop and maintain an efficient, co-ordinated and economical system of electricity transmission; and to facilitate competition in the supply and generation of electricity. This means that any scheme that is proposed, developed and built must meet all these objectives and present value to consumers. The proposal for the new Kincardine North 400kV Substation, based on the information currently available, is the most economic and efficient solution.

6.2 Kincardine North 400kV Substation

The Kincardine North Substation will be rated at 400kV to allow the uprating of the SPT network both in the local area and beyond, which will in turn allow a higher volume of power to flow from renewable generation across the north of Scotland.

Several possible locations were considered for the siting of the new 400kV substation. The preferred option has been identified due to its proximity to the transmission overhead line network, minimising any additional circuit requirements in the area.

Consideration has been given to environmental features within the local area, such as the internationally recognised Ramsar SSSI site on the River Forth, ancient woodlands and garden and designed landscapes. The preferred site takes these considerations into account in the location of the substation.

A summary of the alternative options and subsequent incremental costs are presented in the Table below. Noting our statutory duty and licence obligations, the proposed Kincardine North 400kV Substation is considered to represent the best value for consumers, increasing the ability to economically integrate new renewable sources of power generation across the north of Scotland.

Table 1 – Summary of alternatives

Option	Comment
Southwest of the	Most economic and efficient option, minimising overhead line diversions
Kilbagie Crossing	and underground cable circuit length (i.e. least cost option).
(preferred	
location)	
Paper Mill site	This option would require longer underground cable circuits to the existing
near to the	Kincardine substation and more extensive overhead line works to make the
Kilbagie Crossing	necessary connections to the existing XL Route.
Northeast of the	This option would require longer underground cable circuits to the existing
Kilbagie Crossing	Kincardine substation and would also result in the loss of the native
	woodland in the area.
Southeast of the	This option would require significantly longer underground cable circuits
Kilbagie Crossing	from to the existing Kincardine substation. Additional underground cable
at Windyhill Farm	circuits would also be required to make the necessary connections to the
	existing XL Route. It is also likely to require more complex and expensive
	earthworks to construct the substation platform.
West of the A876	Additional underground cable circuits are expected to be required to make
	the necessary connections to the southern section of the existing XL Route.
	This location could also require the diversion of the Canal Burn and flood risk
	mitigation works due to the potential issues associated with coastal and
	surface water flooding.
Longannet area	This option would require significantly longer underground cable circuits to
	the existing Kincardine substation and complex overhead line diversion
	works around the Kilbagie Crossing.
Existing Kincardine	The option was discounted on the grounds of feasibility and cost, primarily
	due to the size of the substation, the anticipated flood protection measures
	and the scale of the overhead line and underground cable works that would
	be required to achieve the necessary circuit connections.
Hybrid Option	This option would require significant and complex overhead line diversions
	and longer underground cable circuits to connect to the existing Kincardine
	substation. This location would also require the diversion of a water course
	that runs between the Paper Mill and field.