Illustrative Zonal Security Factors for Scottish Islands

Paper by National Grid

Introduction

1. This paper illustrates an option to reflect design variations associated with the Scottish Island connections in transmission charges. The approach calculates a specific zonal security factor for an island connection rather than the standard national value. Capital cost estimates used to determine the potential TNUoS charges are based upon data contained in illustrative design works by Scottish & Southern Energy[1].

Background

2. National Grid has obligations under the Transmission Licence and Electricity Act to:

   - Develop and maintain an efficient, co-ordinated and economical system of electricity transmission and
   - Apply charges that reflect the costs incurred by Transmission Licensees, where reasonably practicable and
   - Facilitate competition in generation and supply.

3. As required by Standard Condition 4 of the Transmission licence National Grid must apply a use of system charging methodology to achieve this and keep it under continuous review and refinement.

4. It is anticipated that there could be a future requirement to connect wind generation located on the Scottish Islands, such as the Western Isles, Orkney and Shetland to the GB Transmission Network.

5. The GB SQSS requires that Transmission Owners provide a double circuit connection to new connecting parties, with a single circuit design variation only permitted when requested by the new connecting party, where the new connecting party accepts the associated access restrictions, and would not effect other users of the system. With the implementation of the shallow 'plugs' connection charging methodology, Users are no longer exposed to the same level of transmission connection asset cost through connection charges (as these charges are recovered through infrastructure charges) and therefore the business driver to request a single circuit connection is diluted. Several potential ways forward have been considered:

   - Apply current Charging Methodologies with no amendment, accepting that the advantages of a shallow connection methodology outweigh disadvantages of reduced cost-reflective signals, for connection assets of parties that choice deign deviations;
   - No enduring amendment to the Charging Methodology with the exception of a one-off zonal approach implemented for the Scottish Island connections such that the cost savings associated with a single circuit connection design are reflected to the customers with an adjustment to the locational security factor applied to that zone;
   - A fundamental change to the transport model and TNUoS methodology to charge on a nodal basis, using nodal security factors;
   - A fundamental change to the Connection Charging Methodology, reintroducing generation only spurs.
   - The introduction of a new access product with an associated modification to the Charging Methodology to introduce a discounted charge for single circuit design variation connections.

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[1] Communication from Scottish and Southern Energy, 2nd May & 22nd June 2005.

6. To facilitate discussion, this paper illustrates what the TNUoS charges may be if transmission connections are made with two of the Scottish Islands, Orkney and Shetland, with the implementation of an exceptional zonal security factor for these island connections.

7. TNUoS charges seek to provide generation and demand Users with locational signals that accurately reflect the true cost of developing and maintaining transmission networks at each location. The TNUoS charge reflects the annual cost of either funding the provision of transmission assets required to support the generation in the north or demand in the south or the reduction in investment caused by delaying the investment due to generation in the south for a year.

8. Due to the lumpy nature of reinforcement of the transmission network, charges are not just a pass through of the local and wider network capital costs but are based in part upon a DC Load Flow transport model. As the cost of the various transmission mediums and voltages vary greatly for an annual unit of transmission capacity, all lines are converted to an equivalence of 400kV OHL. Each Transmission Operator publishes various circuit expansion factors, set at the Price Control and inflated by RPI, annually. Currently, no expansion factors have been developed for either AC or HVDC submarine cables, so this paper uses previous estimates for the capital costs involved.

9. The locational differential is derived in the transport model by assessing the incremental change to requirements of 'standardised transmission kilometres' on the addition of a megawatt of generation at each node in turn. This is converted into annual cost by using an annualised cost of provision on a 'unit' of 400kv OHL. The cost is multiplied by a locational security factor which takes account of the additional capacity of the network to operate following fault outages. For this price control review period the security factor was calculated as 1.8.

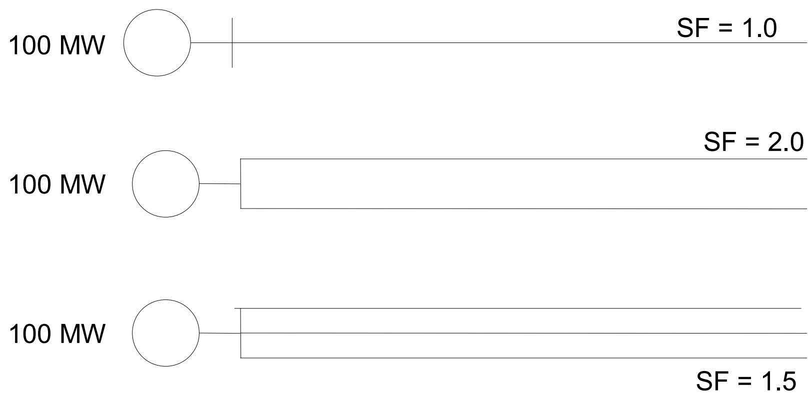
10. The TNUoS figures developed in this paper are for illustrative purposes only as many variables are not accurately known. The capital costs are estimated at this stage and feed into the unit costs and therefore expansion factors, significantly effecting the final values. The HVDC converters are a large capital cost and actual design employed and the decision on the number and capacity of the converter modules will have a large effect, as the costs are to be included into the submarine cable unit costs.

11. It is anticipated that the size of the undersea cable expansion coefficient and its length will result in the island generating its own TNUoS zone.

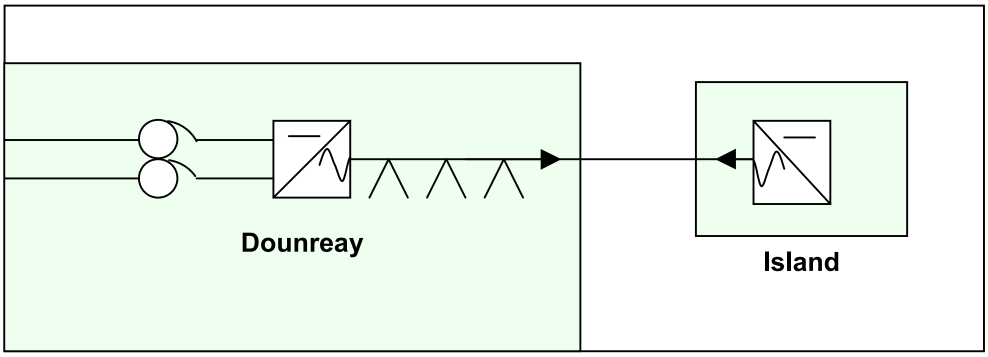
Zonal Security Factor for Islands

12. In the case of the long submarine cables required to connect an island, a unique case exists where there is a significant difference between double and single circuit capital cost. With the strong cost benefit justification, it may be appropriate to reflect this lower cost in the relevant charges. One method proposed is to have a lower, zonal security factor that reflects the lower security provided by a single circuit.

13. As described above, a security factor is calculated, in order to account for network redundancy or security capacity in the Transmission Network. A separate model, SECULF, is run to simulate the effect of faults on the system. For each node, the worse case fault is found that will result in the largest increase in MWkms of transmission. Pre and post fault values are found for all nodes and plotted on a scatter graph and the gradient of the best-fit line represents the single value of the locational security factor for the entire network. A value of 1 would represent no spare capacity and 2, would mean there is double the required intact capacity.



Orkney & Shetland – Worked examples



14. For both Orkney and Shetland it is assumed that the cable has the same capacity as total island generation and there is no redundancy or spare capacity. For Orkney, it has been assumed that an AC cable will be used due to the high unit cost of HVDC converters and relatively short cable length. Likewise, it has been assumed that the Shetland link will be HVDC. Both are terminated at Dounreay Substation, on the mainland.

	Capacity /MW	Cable Length /km	OHL /km	UK connection substation
Orkney	200	50	35	Dounreay
Shetland	600	280	45	Dounreay

15. The same analysis has been performed for both, with the exception of how the HVDC assets are handled. In order to calculate the TNUoS cost it is necessary to estimate the unit capital cost for the submarine cable. This allows conversion to 400kV OHL equivalence to facilitate transport model unit power flow calculations.

16. There is no precedent for how HVDC conductor unit costs are calculated. The modular converters are an integral part of the link and generate far higher cost compared to comparable AC assets, with costs proportional to capacity and distance. This suggests they should be treated like other distance related costs and included into the unit cost of the cable. This ensures that the charges are cost reflective and that one technology is not subsidised.

17. The unit investment cost has been annualised, using a straight line regulatory depreciation model over 40 years, a 6.25% regulated rate of return and a 1.8% annual Opex charge. It is assumed that allowed operating and maintenance costs are similar to National Grid's onshore assets. This gives an overall annual recovery of 8.43%, which is applied to find the tariff expansion coefficient for the submarine cable.

18. The Scottish and Southern Electricity 2006/7 tariff expansion coefficient for 400kV OHL is £10.07 /MWkmyr. The 132kV OHL SSE circuit expansion factor is 2.081, which is used to deal with the short line section in both the examples. The differential MWkm for the line

can be calculated by multiplying the length of the cable and OHL by the relevant expansion factors.

	Unit investment cost of cable /£MWkm	Cost of HVDC converter/ £/kw	Total unit cost of Cable/ £/MWkm	Tariff expansion coefficient /£MWkmyr	Cable Circuit Expansion Factor	Differential /MWkm
Orkney	2600	N/A (AC)	2600	219.2	21.77	1161
Shetland	1250	333	1964	165.5	16.44	4696

19. The submarine cables required for island connections are long and have high unit costs. A SQSS compliant double circuit connection is, therefore, a very large additional cost and would result in an extremely high island zonal TNUoS tarfiff. A customer choice design variation of a single circuit, would decrease the unit cost and the security factor at the island node. For the mainland, a single security factor should be used as all substations are closely interconnected, the links between nodes are broadly comparable in distance and cost and connections are SQSS compliant. This supports the exceptional approach of a zonal security factor for the islands to produce a more cost reflective TNUoS tariff.

20. The island's secure and unsecure marginal kilometres are equal to that of the mainland's node plus the differential of the cable route. This reflects the single link between the system and island node. The ratio of these values is effectively the security factor at the island node, in this case around 1.36 and 1.13.

	Dounreay		Island		Nodal security factor
	Unsecured /MWkm	Secured /MWkm	Unsecured /MWkm	Secured /MWkm	
Orkney	1709	955	2870	2116	1.356
Shetland	1709	955	6405	5651	1.133

21. A substantial and significant factor of the TNUoS tariff estimates is the unit cost of the submarine cable which has both a long length and high capital cost. These figures are not yet accurately known and as a consequence the degree of confidence in their product is reduced.

	Mainland tariff £/kW/yr	Differential due to submarine link £/kWyr	TNUoS – Zonal Security Factor £/kW/yr	TNUoS – NationalSecurity Factor £/kW/yr
Orkney	20.5	15.9	36.4	41.5
Shetland	20.5	53.6	74.1	105.6

22. The connection of additional generation to the North of Scotland can be expected to produce a minor increase the range of TNUoS differentials across the Network. The introduction of a lower, locational security factor will reduce the charges recovered for any island zone but this will be counteracted by the reduced RAV base of a single submarine cable rather than two.

23. The locational security factor appears to allow the reflection of the lower capital costs associated with a single island connection whilst maintaining the locational signals necessary to incentivise cost efficient location of Users.

Renewable Generators in the North of Scotland

24. A paper[2] published by the DTI sets out several potential ways in which high voltage network connections to the Scottish islands could be subsidised in order to encourage renewable generation to meet our environmental obligations. An approach discussed is to adjust the island TNUoS tariff so its differential with the highest mainland zone is halved, which has been illustrated below:

[2] Adjusting Transmission Charges for Renewable Generators in the North of Scotland – A public consulation. DTI July 2005 www.dti.gov.uk/consultations

25. Assuming that the DTI implement the subsidisation of Scottish Island renewables, it is proposed that this additional revenue would be recovered equally across all Suppliers. This is expected to be in the region of an additional £0.1/ MW across the country.

	TNUoS		
	Zonal security factor £/kW yr	Zonal Security Factor & DTI proposal £/kW yr	Existing methodology (SF=1.8) £/kW yr
Orkney	36.4	28.4	41.5
Shetland	74.1	47.3	105.6

Conclusions

26. This paper aimed to illustrate how the current GB transmission charging methodology would calculate TNUoS charging for submarine cable connections with the Scottish Isles and whether an amendment was applicable to take into account the likely single circuit connection. Illustrative examples were examined for the use of a zonal security factor, with a substantial reduction being produced whilst maintaining the locational signals.

27. Several other approaches were identified with future numerical illustration to be performed, to allow comparison.