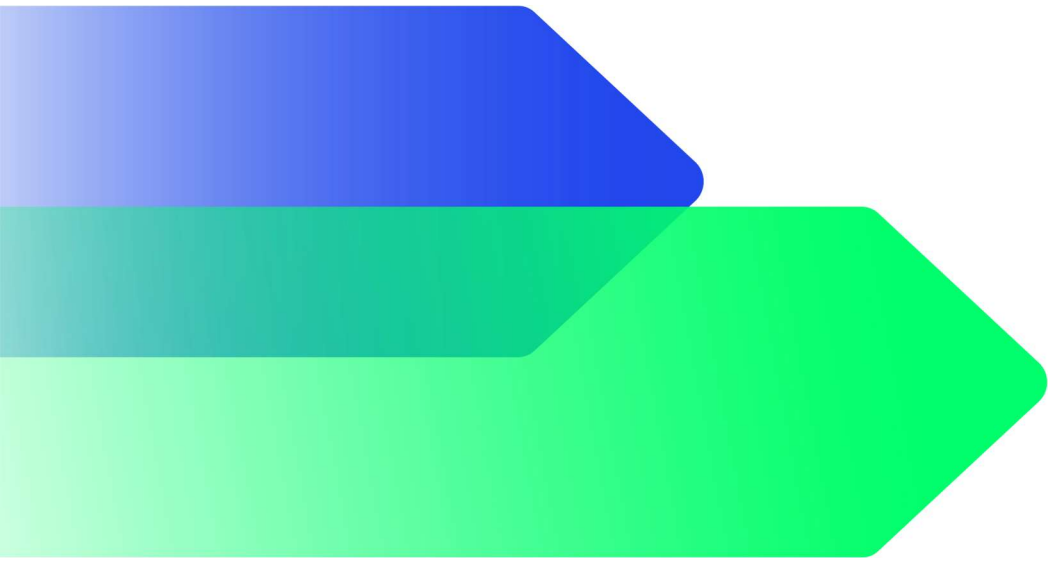
OFFSHORE WIND ACCELERATOR S4Y5

Clarification Question Responses

TWG-C – Sequence Impedance of Subsea Cables

23 April 2024



#	Question	Response
1	Will the project scope include the following components (noting the emphasis on harmonics): a) Dimensional changes in all materials due to manufacturing tolerances and temperature b) Calculation of per unit length impedance matrix in the phase domain: i. Stranding and skin effects in phase conductors ii. Possible frequency dependency in shielding by semiconductive materials iii. Skin effect in lead sheaths iv. Proximity effects between phases v. Sea water skin effect between sheaths and armour vi. Skin effect in armour c) Calculation of per unit length admittances in the phase domain: i. Possible frequency dependency in conductivity of semiconductive materials ii. Possible frequency dependency in phase insulation capacitance and loss factor iii. Possible frequency dependency in sea water conductivity d) Conversion to per unit length frequency dependent sequence impedances e) Conversion to per unit length frequency dependent sequence admittances f) Separate cables for sea water and land portions g) Single point grounding of the land cable h) Isolation and bonding of phase sheaths to armour at the transition from sea to land i) Various system impedances connected at both ends of the cable	In general, the Contractor is recommended to consider how many of the effects can plausibly be considered within the scope of this work, noting that it will not be possible to undertaken exhaustive analysis. On the specific items: a) This can be discussed with the TWG. b) Skin effects in phase conductors and lead sheaths are known to be relevant, as are proximity effects between phases. It is recognised that the contractor will not be able to assess in full detail all of the items, so a prioritisation should be made based on the expected physical significance of each parameter. c) See general note above, but note that frequency dependency of semiconductive materials is a very complex topic. Initial focus is on the positive, negative and zero sequences impedances only. Contractor can propose further works as options. d) Yes e) See c f) The focus here is only on the subsea cable and the net effect of the sea and land cable together does not need to be considered in this scope. g) Out of scope h) Out of scope i) Out of scope

	j) Balanced load currents and unbalanced fault conditions k) Ability to include arbitrary harmonic levels in both voltages and currents l) Calculation of V and I for each conductor along the entire cable including harmonics including possible resonances m) Calculation of losses in all cable materials n) Losses in sea water / soil at transition point o) Resulting temperature rises	j) Focus on balanced load conditions initially k) In scope l) Out of scope m) Out of scope – the focus is impedances not thermal calculations n) Out of scope o) Out of scope
2	What accuracy is desired when modelling the items above?	It is difficult to give a definitive answer to this question – the Contractor should consider how much improvement over the existing approaches can be achieved using the existing methods.
3	How many different cable benchmarks are desired?	Maximum 3 cables
4	Will information be provided on typical dimensional manufacturing tolerances for cables?	The TWG could discuss this with the Contractor during the execution of the works
5	Information on dimensional changes of cables with temperature?	Thermal effects are not in scope
6	Information on frequency dependency of insulation?	This is available in published references
7	Information of frequency dependency of semiconductive materials?	This is highly complex and should be considered out of scope
8	Information on frequency dependency of sea water?	This is out of scope

9	WP3, item 2.0 – “Produce a set of calculated examples for different designs to align with the CIGRE WG. Some of the cases to consider will be suggested by the TWG-C” (a) We are aware of at least one alternative sequence impedance calculation approach. Is the idea to develop a ‘new’ or adapted approach (based on the CIGRE 531 methods) to sequence impedance calculations, then provide example calculations with the application of the ‘new’ or adapted approach? (b) Will the TWG-C provide; i. Full cable builds and technical specifications for the different designs. ii. Sufficient data (such as boundary conditions and convergence criterion) to permit finite element validations, should they be carried out. (c) With regard to clarifications (b) i. and ii., can the Carbon Trust confirm the design data that will be provided?	a) Please build upon the existing methods and provide calculation examples to illustrate how the new approach behaves relative to the existing ones b) We can propose references, for example Cigre TB880 includes several submarine cable designs. On point ii, the contractor could propose something to the TWG for discussion **c)** See above.

carbontrust.com

+44 (0) 20 7170 7000

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