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NIC Competition
Final Interrogation Report

Modular Approach to Substation Construction

submitted by

Scottish Hydro Electric Transmission plc

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1 Project Summary

Scottish Hydro Electric Transmission plc (SHE Transmission) proposes to demonstrate and deploy a permanent substation designed using a Modular Approach to Substation Construction (MASC). SHE Transmission states that the current approach to substation construction differs little from that in use 60 years ago and that the many subsequent innovations in design and civil engineering now allow the opportunity to create a substation which is cheaper, faster to deploy and more suited to GB's low carbon energy future.

MASC seeks to prove, according to SHE Transmission, the following benefits:-

- **Faster deployment:** it is alleged that by maximising off-site construction timescales associated with extensive, on-site civil engineering works are shorter.
- **Improved whole life asset value:** SHE Transmission asserts that MASC substations could offer up to 20% savings over an asset's whole life, compared to conventional builds which equates to savings in the range of £151m to £655m across the GB transmission network.
- **Increased flexibility for network configuration:** it is claimed that the capacity of a substation constructed using the MASC methodology can be easily modified to suit changes in generation plant capacity.
- **Improved environmental impact:** SHE Transmission state that MASC's smaller geographical footprint and off-site construction ensure improvements in visual amenity and less disruption to local communities, wildlife and land.

The project is expected to last for approximately five years, with the aim of providing incremental learning and new standards in substation design and operation. Two innovative learning tools are planned to be introduced through the project; a MASC 3-D Virtual Simulation Tool and a MASC Decision Tool.

The total cost of the project is £3,380k with a NIC funding request of £2,938k and a SHE Transmission compulsory contribution of £338k.

NIC funding is sought to cover only the additional costs of demonstrating the MASC approach for the first time. SHE Transmission indicates that the actual substation project cost will be covered using the established commercial mechanisms for connections.

2 Assessment against Criteria

2.1 Summary of Assessment Criteria

The criteria against which each submission will be assessed are outlined in the Electricity NIC Governance Document. These are listed below:-

(a) Accelerates the development of a low carbon energy sector and/or delivers environmental benefits whilst having the potential to deliver net financial benefits to future and/or existing Customers;

(b) Provides value for money to electricity transmission Customers;

(c) Generates knowledge that can be shared amongst all relevant Network Licensee;

(d) Is innovative (i.e. not business as usual) and has an unproven business case where the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness;

(e) Involvement of other partners and external funding;

(f) Relevance and timing;

(g) Demonstration of a robust methodology and that the project is ready to implement.

The following sections show the key statements made by SHE Transmission in support of meeting each criterion, and summarise challenges to the claims that are made or identify shortfalls with the submission.

2.2 Criterion (a): Accelerates the development of a low carbon energy sector and/or delivers environmental benefits whilst having the potential to deliver net financial benefits to future and/or existing Customers

2.2.1 Key Statements

SHE Transmission's main claims in regard to this criterion are listed below:-

Carbon claims

SHE Transmission recognises that the reduction of carbon emissions are not directly influenced by MASC. However the company argues that such reductions will be facilitated by the project, if it is successful. No quantitative assessment of the impact of such facilitation on carbon reduction is included in the submission.

Environmental benefits

The company states that MASC will deliver environmental benefits by helping to ensure the continued connection of new renewable developments. In addition to this, it maintains that the widespread application of MASC will deliver other environmental benefits, as a result of:-

- an increase in off-site construction (and consequential reduction in on-site construction) leading to a reduction in noise levels, vibration, air pollution, vehicle movements, physical impact on land and road surfaces, road and bridge reinforcement costs, staff site costs, and need for waste disposal,

  and

- reduced construction footprint and the associated civil works as a consequence of smaller foundation requirements and earthworks, and less impact on soil, tree felling, local hydrology, etc.

Quantitative analysis

SHE Transmission has provided a market assessment (undertaken by their consultant - TNEI) and estimates of indicative cost savings.

Financial benefits

The company has stated that the base case cost for a substation project is estimated to be £4.9 million and that MASC can save up to 20% of this cost over the whole asset life of the substation, which equates to a saving of up to £980k. SHE Transmission explains that the net benefits that could be achieved by MASC deployment across GB between 2014 and 2050 across the whole system have been estimated over a range of scenarios. The company asserts that such benefits can be assessed to lie between £151 million and £655 million.

Capacity released

There are no claims in respect of the amount of capacity released or how quickly this would be achieved.

Project replicability

SHE Transmission states that within the proposed project the MASC approach will be used to deploy and demonstrate a 33kV-132kV substation. However, it is maintained that the MASC solution could be applied at any voltage from 132kV to 400kV.

It is assumed by the company that the MASC methodology could be deployed for between 30% to 50% of substations in the GB transmission network from now until 2050.

SHE Transmission also claims that the MASC approach will provide additional options and flexibility which will help ensure that the transmission network can deal with changing demands in the future.

2.2.2 Challenges and Potential Shortfalls

Criterion (a): Accelerates the development of a low carbon energy sector and/or delivers environmental benefits whilst having the potential to deliver net financial benefits to future and/or existing Customers;	
Sub-criterion (a.i) - Carbon claims	Challenge (a.i).1: SHE Transmission recognises that MASC does not directly influence the reduction of carbon emissions but argues that there is indirect facilitation through lower connection costs and quicker connections. More evidence is required to substantiate and sustain this claim.
	Answer (a.i).1: The reduction of carbon emissions, while not directly influenced by MASC, will be facilitated by the project. MASC provides several benefits which will help TOs to continue to provide cost-efficient connections for new, renewable energy developments. These include reduced deployment times and cost reductions. Please see Annex A for details.
	Conclusion (a.i).1: It has been established that the deployment time of a MASC substation will initially be very similar to that of a conventional one although SHE Transmission have suggested a number of reasons why such a deployment time may be reduced in the future. Whilst these reasons are plausible the scale of such improvements remain questionable.

	Similarly the company continues to claim that there will be significant cost savings as a result of the adoption of the MASC approach. This is discussed further in the responses to other challenges. However it is worth noting that the further evidence put forward in regard to such cost savings by SHE Transmission is limited to references made to internal discussions with other SHE Transmission staff and initial interactions with the supply chain. However the detail provided in respect of these is fairly limited – although SHE Transmission did indicate that there was some consistency regarding the information provided by manufacturers.
	Challenge (a.i).2: It should be noted that the indirect facilitation of a reduction in carbon emissions is dependent on the achievement of the overall objectives of the project. Such achievement is the subject of many of the challenges summarised below and hence the reduction in carbon emissions is itself dependent on the responses provided and comfort given regarding these challenges.
	Answer (a.i).2: SHE Transmission agrees that it is not possible to attribute any carbon savings directly to the MASC project and that any indirect carbon benefits will only arise as a result of the project achieving its overall objectives. MASC does deliver wider environmental benefits as described in the submission document; these include a reduction in the number of vehicle movements, depth of civil works required, etc.
	Conclusion (a.i).2: No further comments
Sub-criterion (a.ii) - Environmental benefits	Challenge (a.ii).1: No specific challenge but note that the achievement of the suggested environmental benefits links to many of the other challenges listed below.
	Answer (a.ii).1: No specific challenge given. If more information is required, please contact SHE Transmission.
	Conclusion (a.ii).1: No further comment

Sub-criterion (a.iii) - Quantitative analysis of Carbon/ Environmental claims	Challenge (a.iii).1: No specific challenges
	Answer (a.iii).1: No specific challenge given.
	Conclusion (a.iii).1: No further comment
Sub-criterion (a.iv) - Robustness of financial benefits	Challenge (a.iv).1: SHE Transmission claims that savings of up to 20% of whole life substation costs could be achieved by the successful application of the MASC methodology. However the material provided in the submission to justify this claim is limited and a more detailed explanation and supporting evidence is needed to substantiate it. This should include specific examples of potential cost savings for each aspect of substation cost including linkages between the different types of cost. For example, reduced civil works because of smaller plant size should be supported by evidence that such plant can be obtained without any cost penalty compared to conventional solutions. Other examples or evidence of potential cost savings should be provided for other cost elements. In response to initial clarification questions SHE Transmission has provided a table indicating the estimated cost figures for an AIS substation compared to those for a MASC substation and a brief explanation of the reasons for the differences. SHE Transmission should provide further evidence that there is a reasonable likelihood that the suggested cost reductions are achievable and that where there are cost increases (as is the case for certain elements within the substation) these have been prudently estimated.
	Answer (a.iv).1: The assumption of 20% has been derived from initial engagement with several manufacturers and an internal review of the approach's application. Cost reductions have been identified in relation to reduced land and civil requirements, combined with the significantly reduced construction time. The additional works required to manufacture and commission the MASC equipment does result in increased costs for the electrical equipment. However, this is more than off-set by the reductions in civil, project management and transport costs. Phase 1 of the project will see the design, cost and programme for the equipment being developed and confirmed. For further details see Annex A.

	Conclusion (a.iv).1: A further breakdown of present and expected future costs has been provided. This identifies, as mentioned above, that it is expected that the costs of the electrical equipment will be higher than for the conventional case with savings in civil, project management and transport costs. Whilst these assumptions seem fairly plausible it remains of concern that limited quantitative evidence has been presented to support the reasonableness of these assumptions. However as noted in Conclusion (a.i).1 SHE Transmission has commented that there was some consistency regarding the information provided by manufacturers.
	Challenge (a.iv).2: In the submission it states that "The MASC project aims to take the best of … modular approaches and seek additional benefits through the adoption of new construction techniques, protection systems, communications and auxiliary services". Other than references to international examples it is not clear what specific examples of the modular approaches, construction techniques, protection systems, communications, auxiliary services or other aspects of the substation infrastructure will be utilised as part of the project and how this results in up to 20% cost reductions or shorter implementation timescales. Answers to clarification questions have started to provide this information but these should be integrated into an overall comprehensive response.
	Answer (a.iv).2: The key benefits from the MASC project arise from the integrated application of a series of innovations. The functional specification developed in the NIA project will be refined by input from a range of stakeholders. During early engagement with the supply chain and discussion with internal stakeholders, we identified a number of potential innovations. These related to civil, construction, protection and auxiliaries elements. As identified previously, the application of a number of these innovations result in overall cost savings of up to 20%. For further information see Annex A.
	Conclusion (a.iv).2: See also Conclusion (a.i).1 and (a.iv).1. At this stage only a relatively small number of potential technical innovations have been put forward although it should

	be noted that SHE Transmission refers to these as examples rather than a comprehensive list. The main examples quoted are modularisation of components, screw pile foundations and In-factory installation of protection and control systems. There are references to aspects of temporary access roads, prefabricated bunding and rationalisation of auxiliary services as other areas where innovation may be possible. The extent to which this project is truly innovative remains an area of concern. SHE Transmission also convincingly argues that much of the innovation within the MASC project relates to reviewing and updating operational procedures. This would be required to facilitate and allow the use of a modular approach to substation construction.
	Challenge (a.iv).3: SHE Transmission suggests that, for a number of reasons, there could be a reduction in the time necessary to undertake planning and consent processes when a modularised substation is utilised. In addition it is mentioned that the time for on-site construction may also be reduced as a result of prior factory activity. The total project time (from inception to commissioning) will also need to include the factory build time so it is not clear from the submission that there would be an overall reduction in the time required to construct a substation between the conventional approach and the modularised one. PPA Energy questioning on this topic resulted in SHE Transmission providing a high level programme illustrating the timeframe from start to finish for an AIS and a MASC substation. This shows that, at present, the AIS and MASC programmes complete at approximately the same time. SHE Transmission provided several reasons why there was the potential for the MASC solution timescale to reduce in the future. Whilst these are plausible there is currently limited evidence that such improvements will actually be achieved.
	Answer (a.iv).3: The established AIS and first-time MASC solutions described within the high-level programme show similar construction completion timescales. As the modular approach becomes integrated into business as usual, there is potential to reduce construction to deployment times. For example, standardisation of design methodology will create sustainable time savings for future projects. Please see Annex A for further details.
	Conclusion (a.iv).3:

	SHE Transmission suggests that the MASC solution has the potential to reduce overall deployment timescales from the use of standardised designs, modular manufacture, the removal of construction and commissioning contingencies, and reduced timescales for planning and consenting processes. As previously mentioned, whilst these reasons are plausible the scale of such improvements remain questionable.
	Challenge (a.iv).4: The company suggests that a MASC substation may offer better whole life value than the conventional approach partially because of lower operating and maintenance costs. This appears to result from the assertion that off-site construction and commissioning would result in improved quality and reliability, and the existence of "spare" modules would allow them to be swapped to facilitate cheaper and quicker maintenance. Little or no evidence is put forward to support these assertions and the ideas are not developed in the business case.
	Answer (a.iv).4: As much of the MASC equipment is fabricated and commissioned in a clean, controlled environment rather than on-site, there is a lesser risk of equipment failure caused by contamination. This improves reliability in assets and therefore creates a reduction in operating costs. Other savings are anticipated due to savings on land purchase (because of the smaller footprint requirements), reduced need for security, lighting, fencing, travel and subsistence costs for construction staff, and reduced road reinforcement and vehicle movements. Strategic "spares" for key components such as transformers are already held by TOs to allow them to respond to equipment failures. When MASC is deployed on a large scale, there is the potential for "spare" modules to be retained by the TOs. The modular nature of the solution, with a high degree of standardisation should allow "modules" to be swapped relatively quickly and easily compared with conventional equipment. Information supplied by the supply chain supports this view.

	Conclusion (a.iv).4: The key points here are factory production leading to higher quality equipment being installed and the use of "spare" modules. In the case of the former reason it would have been useful to have examples from other industries where such an approach demonstrated that such benefits could actually be achieved. For "spare" modules it is still unclear the number of types of modules that would need to be retained and hence the strength of the deliverability and business case for it.
	Challenge (a.iv).5: It is suggested in the submission that the smaller size and certain of the characteristics of modular substations may aid and accelerate the planning and consenting process for their construction. This suggestion does not yet seem to have been validated with appropriate stakeholders.
	Answer (a.iv).5: SHE Transmission does assert that the size and characteristics may aid planning and consent. Work to verify this is an essential part of the learning from Phases 1 and 2 of the MASC project. A programme of engagement is proposed for the early stages of the project to seek input from key stakeholders related to the planning process. This engagement will help us consider as wide a range of views possible. See Annex A for further information.
	Conclusion (a.iv).5: SHE Transmission has put forward a large number of reasons supporting this assertion and also indicates that there has been engagement with the company's environmental management team. Whilst this is useful, external verification seems to have been left until the project itself, should it be funded. It would have been helpful if some initial such validation had been undertaken during the project submission and review process.
Sub-criterion (a.v) - Capacity released and how quickly (if applicable)	Challenge (a.v).1: There are no claims in respect of the amount of capacity released or how quickly this would be achieved.
	Answer (a.v).1: SHE Transmission is not claiming that extra capacity will be released as part of this project. Instead, it offers value for money to customers, extensive learning to the industry and wider environmental benefits.

	Conclusion (a.v).1: No further comment
Sub-criterion (a.vi) - Replication	Challenge (a.vi).1: The estimated benefits of the MASC methodology have been based on the assumption that it could be deployed at between 30% to 50% of substations in the GB transmission network from now until 2050. However it is not clear how this assumption has been arrived at. SHE Transmission refers to network conditions and requirements, project location, planning and consenting issues, and a review of information from sources including NGET TEC register and DNO Long Term Development Plans as factors which have been taken account of in making these assumptions but the process remains opaque. Further clarification as to how these figures have been derived is required.
	Answer (a.vi).1: The MASC approach can be applied to the full range of substation projects. The benefits from MASC come from off-site manufacture and commission, reducing land requirements, civil works and construction times. A standardised design approach (and therefore serialised production) creates potential for economies of scale. The extent to which the MASC solution can be applied will be dependent upon a number of factors, these include: • The network conditions and requirements for the project such as; number of incoming and outgoing circuits; transformer rating, voltage rating; and requirements for additional equipment such as SVCs and statcoms. • The location of the project i.e. rural vs. urban. Space and access requirements are key factors. • Planning and consenting issues. For example, these could include special aesthetic requirements and weight limits of roads. In order to realise the potential benefits from the MASC approach, the design needs to strike a careful balance between maximising the potential for factory-based manufacture and ensuring that standard, non-specialised transport arrangements are possible. We do not expect that every substation project will be eligible for MASC. For example, if conditions dictate that a bespoke approach is best for a particular substation project, then MASC would not be used. However, there are many projects where a

	standardised approach would be suitable. In simple terms the MASC solution has greatest potential in projects which have relatively straightforward electrical requirements, lower voltages and ratings. Technically simple electrical requirements will naturally allow greater replication and ease of transportation. It is recognised that the MASC solution will not be suitable for every substation project. For this reason, we will incorporate a tool within our knowledge dissemination programme that allows other licensed network operators to evaluate the suitability for MASC at any given location. Based on the market research carried out by TNEI (contained in Appendix 6a), it is estimated that the MASC solution could be applied to between 30% and 50% of potential future projects. The early learning from Phase 1 of MASC will help to validate this assumption.
	Conclusion (a.vi).1: Whilst the response provides a qualitative explanation of relevant factors, it remains unclear from it how the 30% to 50% assumption has been derived. However SHE Transmission has also indicated during discussions with the Expert Panel that it believes that the MASC approach is most suited to relatively simple substations and connection arrangements and it has undertaken a high level review to gain some insight into the proportion of future substation construction project that are likely to fall within this category and that this has informed the range that has been selected. Detailed information on this has not been provided but this does provide some re-assurance regarding it.
	Challenge (a.vi).2: SHE Transmission states that although the demonstration within the MASC project is for a 132kV to 33kV substation the solution could be applied at any voltage from 132kV to 400kV. Indeed the benefits calculated in the business case (at least in the case of transmission reinforcement) seem to make that assumption. SHE Transmission appears to have given limited consideration to the issues associated with scaling up a 132kV solution to higher voltages. The company suggests that there are international examples of applications at such levels. However the list provided in the submission contains few above 200kV and none at the 400 kV level.
	Answer (a.vi).2:

	MASC challenges existing substation design and construction methodology. It is therefore imperative that we select a site for the demonstration project that inspires investor-level confidence within the industry. Through this MASC will be integrated into licensed network operators' asset portfolios. For MASC demonstration, SHE Transmission has opted to use a single 132kV connection bay substation supporting a new generator, which requires a single transformer. This is representative of new renewable generation connection, and will allow many of the potential benefits from MASC to be demonstrated. The NIC project will see the **demonstration** of the MASC solution and will provide the necessary detailed learning to support the development of the method to "business as usual". It is anticipated that many of the elements of the project will be directly replicable at the higher voltages. When discussing 275kV and 400kV solutions it is recognised that; • the transformers are larger and will present additional challenges especially around logistics; • discussions with manufacturers show that there is some international experience in providing modular solutions at higher voltages (see Appendix 3 of the submission document); • additional design and evaluation will be required to apply MASC at 275kV and 400kV levels. The MASC project will provide much needed confidence in progressive substation build techniques and will also inform design, construction, commissioning, maintenance and operational philosophies. Knowledge capture will be directly applicable to higher voltage levels.
	Conclusion (a.vi).2: The response provides the background to the selection of 132 kV for this trial and, whilst some differences that would arise from applying it at higher voltages are noted, it still does not appear to recognise the scale of the challenge that would need to be addressed.
	Challenge (a.vi).3: SHE Transmission claims that one of the benefits of a modular substation is the added flexibility and optionality it offers in adapting to network changes required as a result of the repowering or decommissioning of existing

	generation leading to the consequential decommissioning or relocation of substation capacity. Whilst it is recognised that the proposed modular approach would be a step towards this it remains questionable whether such flexibility would be achievable in practice when substations are likely to retain a significant element of individuality.
	Answer (a.vi).3: The energy future of the country is unpredictable, but it is likely that a greater degree of network flexibility will be required to accommodate the needs of customers and generators. SHE Transmission believes that MASC can be a significant method with which to create this flexibility compared to conventional substations. Please see Annex A for details.
	Conclusion (a.vi).3: The response provides a number of convincing reasons why the suggested flexibility would be beneficial but does not really address the question which was the practical deliverability of such flexibility and whether providing this could challenge any of the other claimed benefits of the approach.
	Challenge (a.vi).4: Tables 1, 2, 3, and 4 in the market assessment appendix refer to the three transmission operator areas in GB. One row in each of the tables is labelled NGET. However, since the methodology used means that all of the estimated number of projects are 132 kV connections and as in England and Wales 132 kV is a distribution voltage this line could, perhaps, more accurately be called "England and Wales". As a result any benefits that arise from these projects as a result of the use of the MASC approach accrue to the customers of the DNOs rather than those of the TOs. SHE Transmission should clarify this point.
	Answer (a.vi).4: As identified, the 132kV projects in England and Wales are delivered at distribution level. The tables identified will be amended when the project is resubmitted. Appendix 6a indicates that 26 of the 152 projects identified are potentially being developed by DNOs in England and Wales. Benefits from these projects will accrue to DNO customers, however, it should be noted that the benefits for TOs and DNOs will both have the potential to reduce Use of System charges for customers.

	For the sake of clarity and to aid understanding these projects were included within the overall portfolio of potential projects in order to calculate the potential benefits.
	Conclusion (a.vi).4: This is a useful clarification.
	Challenge (a.vi).5: Tables 6, 7 and 8 in the market assessment appendix use the expected number of transmission reinforcement projects in Scotland to estimate the number of such projects in England and Wales based on the forecast transmission reinforcement expenditure in the two areas. However the vast majority of the Scottish projects are at higher voltages than 132 kV. Concern has been expressed in challenge (a.vi).2 above regarding the scalability of the MASC approach to such voltages and hence this raises doubts about the scale of the claimed overall benefits to transmission customers.
	Answer (a.vi).5: The MASC project is seeking funding for the additional costs of deploying this method for the first time. This is likely to be a 132kV connection to a new generation development, which will allow many of the potential benefits from MASC to be fully demonstrated. SHE Transmission recognises that the MASC solution is not appropriate for all substation projects. The benefits from the modular approach are partly realised by maximising factory assembly within the limits of standard transportation arrangements. The size and weights of individual components (transformers, circuit breakers, etc) become progressively larger as voltage levels increase. Similarly, higher voltage substations are fewer in number and tend to form key “nodes” in the network so may have more necessity of bespoke arrangements. However, there is some international experience which demonstrates that MASC can be applied at higher voltages. Even in bespoke overall arrangements though, elements of MASC learning is applicable to higher voltage projects e.g. off-site assembly and commissioning of protection and control systems, modularisation of SCADA and RTS equipment, and off-site assembly of battery and other auxiliaries. Similarly, some of the new approaches to transport and civil works could be applied to the 275kV and 400kV systems. MASC application to elements of these

	projects will still help to reduce both costs and time, and therein, produce benefits for customers.
	Conclusion (a.vi).5: The company's response seems to accept some of the thrust of this challenge. Interestingly it is suggested that elements of the MASC approach could be applied at higher voltages even if it could not be applied in its entirety although this idea is not developed in any detail.

2.3 Criterion (b): Provides value for money to electricity transmission Customers

2.3.1 Key Statements

As mentioned above, SHE Transmission claims that MASC deployment could save up to 20% in whole life costs compared to traditional substation projects and that the methodology can be used for both the new connection of renewables, and for new asset deployment and replacement on the established network.

SHE Transmission's main claims in regard to this criterion are listed below:-

Proportion of the benefits attributable to the transmission system

SHE Transmission lists the potential beneficiaries of the MASC approach as follows:-

- Customers – who ultimately fund investment in substation infrastructure through transmission charges

- Transmission operators – through reduced capital and operating costs, increased flexibility, reduced construction duration, and the optimisation of asset life with requirements. SHE Transmission indicates that many of these benefits will flow directly to customers.

- Other network licensees – as previously mentioned 132 kV is a distribution voltage in England and Wales so if the project were successful the learning would be beneficial to distribution network operators (DNOs).

- Renewable developers – who would benefit from reduced infrastructure costs. SHE Transmission states that such developers are key customers and stakeholders for all transmission operators.

The company has not indicated what proportion of the potential benefits of the MASC methodology that it estimates would flow to transmission customers.

How learning relates to the transmission system

SHE Transmission claims that the use of modular substations will provide benefits to all transmission network customers.

It goes on to explain that, in its view, the direct impact of the MASC method will mark a step change away from historical, bespoke substation technical designs to a standardised, "pre-cut" approach. It maintains that the benefits of this are measurable in terms of cost savings, and reduced construction timescales for substations. Such benefits, the company asserts, will result from the reduced capital and operational costs of MASC.

Approach to ensuring best value for money in delivering projects

SHE Transmission indicates that the scale and cost of the project compare favourably with the value of the knowledge and learning that the project will provide and states that the project will be delivered at a competitive cost. Total project costs are estimated to be £3.38 million with a NIC funding request amounting to £2.938 million and SHE Transmission making a contribution of £338k. Most of the remaining funding for this project will be met by a renewable generation developer in accordance with industry standard charging arrangements.

Potential benefits are summarised by the company as follows "MASC substations could offer up to 20% savings over an asset's whole life, compared to conventional builds. This equates to £151m to £655m savings across the GB transmission network".

The company also states that:-

- There are no costs associated with protection from reliability or availability incentives.
- The MASC project will involve extensive stakeholder engagement to ensure that solution meets as many of their requirements as possible.
- The MASC project will fall under SHE Transmission's established governance processes to ensure value for money.

2.3.2 Challenges and Potential Shortfalls

Criterion (b): Provides value for money to electricity transmission Customers;	
Sub-criterion (b.i) - Proportion of benefits attributable to transmission system (as opposed to elsewhere on supply chain)	Challenge (b.i).1: See challenges (a.vi).1, (a.vi).2, and (a.vi) 4.
	Answer (b.i).1: The MASC methodology is applicable to the full range of substation projects including new, renewable connections and also refurbishment or reinforcement projects initiated by transmission operators. Any benefits which arise from cost savings in the delivery of these TO-initiated projects will benefit customers directly. Elements of the cost of providing renewable connections are paid by the developer with the remainder being borne by transmission customers. The mechanism for establishing these charges and the sharing arrangements between developers and customers is identified in the CUSC. Each site has its own characteristics with the costs and sharing arrangements being dependent on the nature of the connections and the works required. However, the MASC solution has the potential to reduce the cost of the entire project and benefit both developers and transmission

	customers. The cost apportioning between parties will be determined on an individual site basis in accordance with the CUSC methodology. Please also see Annex A.
	Conclusion (b.i).1: See responses to challenges (a.vi).1, (a.vi).2, and (a.vi) 4
Sub-criterion (b.ii) - How learning relates to the transmission system	Challenge (b.ii).1: See challenges (a.vi).1, (a.vi).2, (a.vi) 4, and (a.vi) 5.
	Answer (b.ii).1: MASC can be applied to both projects for new, renewable generation developments and for upgrades and reinforcements within existing networks. All of the learning from the project will be related to the transmission system. In addition learning may be relevant to other network licensees such as DNOs in England and Wales. Please also see Annex A.
	Conclusion (b.ii).1: See responses to challenges (a.vi).1, (a.vi).2, (a.vi) 4, and (a.vi) 5.
Sub-criterion (b.iii) - Approach to ensuring best value for money in delivering projects	Challenge (b.iii).1: As mentioned above SHE Transmission claims MASC substations could offer up to 20% savings over an asset's whole life, compared to conventional builds, which the company indicates equates to £151m to £655m savings across the GB transmission network. However this is on the basis of the methodology being applicable to 50% of transmission substations between now and 2050. If projected savings are assumed to be 10% and applicable to 30% of the substations the savings reduce to £91 million. This wide range of difference in projected benefits suggests that the business case for the project may still be immature and that there is a high level of uncertainty in regard to the project with the risk that even the lowest estimate of benefits may be subject to significant erosion.
	Answer (b.iii).1: The range of benefits available from the MASC project is directly related to the number of substation projects which will be developed in GB to 2050. There are a wide range of factors which could influence this – for this reason, National Grid's Future Energy Scenarios was used as a basis for projecting future uptake. Even at the lower end of the benefits projection, the project represents good value for customers and has the potential to deliver savings. The

	energy future of the country is unpredictable, but it is likely that a greater degree of network flexibility will be required to accommodate the needs of customers and generators. SHE Transmission believes that MASC can be a significant conduit to this flexibility compared with conventional substations.
	Conclusion (b.iii).1: Essentially SHE Transmission argues that although there is a wide range to the level of the potential benefits the project remains – particularly because of its low costs – good value for money even if the benefits are at the lower end of that range.

2.4 Criterion (c): Generates knowledge that can be shared amongst all relevant Network Licensee

2.4.1 Key Statements

SHE Transmission's main claims in regard to this criterion are listed below:-

Potential for the generation of new or incremental learning

The company states that the project has been designed to optimise learning and knowledge within every phase. Key learning objectives are stated to be:-

- New substation requirements – production of detailed design requirements and functional specification.
- Performance, operability and maintenance requirements – including additional monitoring of the new equipment during the operational phase.
- Future usage options – developing a suite of potential sites for future MASC deployment.
- Supply chain capability – supplier engagement to identify a range of solutions and innovative technologies.

Applicability of learning to other Network Licensees

According to SHE Transmission knowledge from the project will form the basis for investment level confidence amongst GB network licensees, planning authorities and the supply chain in the MAC methodology.

Proposed IP management

The company states that it is the intention that the work undertaken using NIC funding will adhere to the NIC default IPR arrangements. However, this will be subject to confirmation depending upon the final outcome of the commercial negotiations with equipment suppliers, project partners and other stakeholders.

Credibility of proposed methodology for capturing learning from the trial and plans for disseminating

SHE Transmission indicates that a clearly defined knowledge dissemination programme has been developed which will include progress and completion reports, hosted dissemination events and webinars, conferences, use of the ENA learning portal, a dedicated project page on the SSEPD website, and press releases at key milestones.

A MASC decision tool will be developed aimed at providing a cost-benefit analysis of a modular substation in comparison to a conventional build one for a given set of parameters.

It is also planned to develop a MASC 3-D virtual simulation tool so that a user can "walk" around the substation and be provided with information about the plant within it. This is intended for both training and dissemination.

SHE Transmission's intend to use a standard framework to capture results from the project.

2.4.2 Challenges and Potential Shortfalls

Criterion (c): Generates knowledge that can be shared amongst all relevant Network Licensee;	
Sub-criterion (c.i) - Potential for new/incremental learning to be generated by the project	Challenge (c.i).1: No specific challenges
	Answer (c.i).1: No specific challenge given.
	Conclusion (c.i).1: No further comment
Sub-criterion (c.ii) - Applicability of learning to other Network Licensees	Challenge (c.ii).1: No specific challenges
	Answer (c.ii).1: No specific challenge given.
	Conclusion (c.ii).1: No further comment
Sub-criterion (c.iii) - Proposed IP management and any deviations from default IP principles	Challenge (c.iii).1: No specific challenges
	Answer (c.iii).1: No specific challenge given.
	Conclusion (c.iii).1: No further comment

Sub-criterion (c.iv) - Credibility of proposed methodology for capturing learning from the trial and plans for disseminating	Challenge (c.iv).1: No specific challenges
	Answer (c.iv).1: No specific challenge given.
	Conclusion (c.iv).1: No further comment

2.5 Criterion (d): Is innovative (i.e. not business as usual) and has an unproven business case where the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness

2.5.1 Key Statements

SHE Transmission's main claims in regard to this criterion are listed below:-

Justification that the project is truly innovative

The company states that the MASC project is innovative in that a permanent, modular substation has never been implemented at this scale on the GB electricity network.

Justification that NIC funding is required and credibility of claims

In its submission SHE Transmission indicates that MASC is a project that it could not undertake as part of its normal course of business, because proof of concept concerning the deployment of a fully modular approach for a permanent substation has never been established in GB. Hence NIC funding for the MASC project is key in substantiating the benefits of this approach in a controlled environment for several reasons including the fact that SHE Transmission's asset acquisition policy takes a conservative view (as does that of other network licensees), to ensure best value for money for customers and to ensure network reliability. Therefore MASC is suited to the protection offered by NIC funding.

Identification of project specific risks

SHE Transmission has provided a risk register as part of its submission and explained its approach to risk management.

2.5.2 Challenges and Potential Shortfalls

Criterion (d): Is innovative (ie not business as usual) and has an unproven

business case where the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness;	
Sub-criterion (d.i) - Justification that the project is truly innovative	Challenge (d.i).1: As mentioned above, SHE Transmission claims that this project is innovative because a permanent, modular substation has never been implemented at this scale on the GB electricity network. However, the case for regarding this as a "business as usual" project should be considered. This results from the projects relatively low cost, the potential benefits for manufacturers, and the scale of the claimed benefits for transmission operators and ultimately their customers.
	Answer (d.i).1: Substation design, construction and operational techniques have changed very little over the last sixty years, with only limited, conservative changes to equipment and operating practises. This project represents a "step change" in the way we approach substation construction projects. This "next-generation" approach inherently signifies additional cost and risk to first time deployment. Without the support from NIC it would not be possible for an individual transmission operator to progress this approach. Similarly, NIC funding allows knowledge to be shared amongst all network licensees; this gives the potential for further economies of scale and will encourage greater supply chain involvement.
	Conclusion (d.i).1: SHE Transmission argues that this project represents a "step change" for substation projects. However in challenge (a.iv).2 it is noted that the company has suggested at this stage only a relatively small number of potential technical innovations although some other possible ones have been mentioned. The main examples quoted are modularisation of components, screw pile foundations and In-factory installation of protection and control systems with references to aspects of temporary access roads, prefabricated bunding and rationalisation of auxiliary services as other areas where innovation may be possible. Also as noted in Conclusion (a.iv).2 SHE Transmission has set out some reasonably convincing reasons that much of the innovation within the MASC project relates to reviewing and

	updating operational procedures - which would be required to facilitate and allow the use of a modular approach to substation construction. However there remains a residual concern as to whether the project has a sufficient element that is truly innovative.
Sub-criterion (d.ii)- Justification that NIC funding is required and credibility of claims	Challenge (d.ii).1: See challenge (d.i).1
	Answer (d.ii).1: Realisation of the full potential from the MASC approach and integration into 'business as usual' across GB will require the support of all relevant licensees. Support from the NIC permits SHE Transmission to capture and share knowledge gained during the trial to **demonstrate** the benefits from a modular solution. From experience in previous projects such as Active Network Management, we understand that successful demonstration of technology is a highly effective tool for securing the interest and participation of other licensees. See also Answer (d.i).1
	Conclusion (d.ii).1: The company argues that NIC funding will be a tool to capture the attention of other licensees which is a requirement for successful implementation. See the response to challenge (d.i).1
Sub-criterion (d.iii) - Identification of project specific risks (including commercial, technical, operational or regulatory risks)	Challenge (d.iii).1: See challenge (g.ii).1
	Answer (d.iii).1: A project-specific risk register has been developed to capture a wide range of risks for the project and identify appropriate mitigations. This risk register will continue to be developed as the project progresses toward construction. This forms a key element of the project governance requirements and is an integral element of reporting to the Innovation Steering Board. Please see Appendix 8 of the main submission document which holds a copy of the risk register.
	Conclusion (d.iii).1:

	See response to challenge (g.ii).1

2.6 Criterion (e): Involvement of other partners and external funding

2.6.1 Key Statements

SHE Transmission's main claims in regard to this criterion are listed below:-

Appropriateness of collaborators

SHE Transmission asserts that the MASC project does not require the recruitment of formal project partners. It goes on to say that the project does not require a formal partner arrangement although the project team will work with various organisations who themselves are not required to seek other collaborators.

External funding

NIC and SHE Transmission funding is only to cover the additional costs of delivering a MASC build for the first time. As previously mentioned most of the remaining funding for this project will be met by a renewable generation developer in accordance with the industry standard charging arrangements although this developer does not yet seem to have been identified.

In the absence of partners, no other external funding has been disclosed.

SHE Transmission also states that it has engaged with internal stakeholders and with the transmission supply chain to ensure in-house and procurement collaboration.

Effectiveness of process for seeking and identifying new project partners and ideas

SHE Transmission has outlined that it conducts a programme of stakeholder engagement which includes ongoing communication with the supply chain, and attendance at industry events. However on this occasion this seems not to have resulted in a project proposal that in SHE Transmission's view requires partner participation.

2.6.2 Challenges and Potential Shortfalls

Criterion (e): Involvement of other partners and external funding;	
Sub-criterion (e.i) - Appropriateness of collaborators (including experience, expertise and robustness of commitments)	Challenge (e.i).1: Whilst there are no project partners in this project SHE Transmission states that there are a number of project supporters from within the supply chain – [redacted]. The company recognises support is required from within the supply chain so that essential technical solutions required for MASC are made available to transmission operators. It has been stated in the submission and in answer to subsequent PPA Energy questioning that there have been discussions between the equipment

	manufacturers and the company at senior level regarding this project and the adoption of a modular approach to substation development. It has also been indicated that technical information and previous examples have also been provided by the manufacturers. Some brochures have also been provided. However little evidence has been given of the scale of the information that has been provided or the extent to which its applicability has been tested for both SHE Transmission and other GB transmission and distribution licence holders.
	Answer (e.i).1: SHE Transmission has long-standing relationships with [redacted] for the supply of substation equipment. The [redacted] manufacturers identified have each been awarded places on SHE Transmission's framework as part of consortia to deliver a programme of substation infrastructure in the north of Scotland. This programme has a cumulative value of around £600m and is a cornerstone of SHE Transmission's investment and upgrade programme. SHE Transmission works closely with its supply chain partners and has regular meetings with key suppliers at director level to ensure delivery of this programme of works. Potential for a modular approach has been identified at these sessions and there is a strong willingness to support the MASC project's development and adoption into business as usual. All [redacted] manufacturers have provided information on their previous experience in modular substations and have also identified that the equipment could be applied in GB. This engagement has served to highlight a number of potential risks; these have been identified on the risk register and will be closely managed during Phase 1 of the NIC project. The design and development planned for Phase 1 of the project will allow SHE Transmission to develop a more detailed understanding of the risks and benefits of the MASC solution. SHE Transmission will only proceed with procurement of the Modular Substation if it is confident that the benefits can be realised with an acceptable level of risk. If the costs and risks are still at an unacceptable level then the planned project will be delivered using conventional equipment. The ongoing progression of the MASC project will then need to be reviewed.
	Conclusion (e.i).1: This response has described the interactions with the large equipment suppliers. There seem to have been a number of

	such interactions but the evidence of it within the submitted proposal is more limited consisting of letters of support, and a number of references to figures used in the business case where it is stated that they have been derived following initial discussions with the supply chain. It is a matter of judgement as to whether this is sufficient evidence of support from manufacturers.
	Challenge (e.i).2: Contacts with manufacturers other than the [redacted] project supporters seem to have been very limited. In response to a clarification question SHE Transmission have indicated that in developing the submission there had been input from [redacted]. Again, however, limited evidence has been presented regarding the depth and detail of the interaction with these parties.
	Answer (e.i).2: Please note that discussions with the organisations listed above should be regarded as commercially sensitive and remain confidential – we request that this section is redacted if published. [redacted] suppliers have been approached for discussions regarding MASC. We have requested information regarding applicability to the GB market, and asked for information gained in deployment of a modular approach in other countries where appropriate. These discussions have been invaluable in providing further information on the range of technology available and how it can be applied. This has also been useful in providing information on the ongoing operation of modular equipment ie management of spares etc. The functional specification developed through the NIA project will provide a basis for a more formal procurement exercise which will potentially allow other suppliers to become involved in addition to those who have already contributed to the project. The development of a secure and robust supply chain is critical to the overall success of the MASC project. However, recruitment of a formal partner in the supply chain could preclude fair competition and value in the marketplace and therefore we do not wish to seek formal project partners from the supply chain at this time.
	Conclusion (e.i).2: SHE Transmission state here that, at this stage, the recruitment of a formal partner in the supply chain could preclude fair

	competition and value in the marketplace and therefore they have not sought formal project partners from the supply chain at this time. This contrasts with the approach used by certain other applicants. This has probably limited the extent to which the project has been specified at this stage. Hence there is a trade-off between the time that project partners (or their equivalent) are selected and the level of project development at the application stage. Both of these approaches have their advantages and disadvantages
	Challenge (e.i).3: Unusually there are no project partners in this project. Such partners often bring a broader view and different insights to a project. It is noted that no other transmission operators or distribution network operators have been included as partners. SHE Transmission asserts that other partners are not required but does not explain its reasoning for this conclusion.
	Answer (e.i).3: During Phase 1 of the MASC project, SHE Transmission will carry out an extensive programme of stakeholder engagement which gathers input from a wide range of interested parties. This will include seeking input from the other TOs and DNOs. This will be supplemented by the learning outputs from the associated NIA project which is developing a functional specification for the modular approach. The NIC project is focussed on the additional cost of the first **deployment and demonstration** of a modular substation. The MASC project will be used to provide new substation infrastructure either for a new renewable connection or planned reinforcement project. SHE Transmission therefore has a contractual requirement to deliver these projects within the agreed timeframes in order to deliver the new capacity. Whilst, SHE Transmission are happy to seek input from stakeholders and share learning with other licensees, it is essential that they remain in sole control of the delivery of the project to ensure its successful delivery. From previous experience in areas such as Active Network Management (ANM), a successful demonstration of the technology is a highly effective tool for securing the interest and further participation of other licensees. This demonstration supported by a coordinated programme of learning events has resulted in ANM being widely adopted by the other DNOs.

	Conclusion (e.i).3: This does not really explain why other partners - particularly other TOs or DNOs have not been included. However in discussions with the Expert Panel the company has indicated that its preference is to seek engagement with DNOs and TOs once an initial specification has been derived as this is more likely to gain a response. A potential danger of this approach is that the initial specification may not fully take account of wider issues and may be too locally based. However SHE Transmission state that their aim is to produce a specification that has wide and general applicability throughout the industry.
	Challenge (e.i).4: Another vital component of this project is gaining the agreement of a suitable renewable generator to this approach being used for their connection. It is not clear what discussions there have been between the company and such generators to test the acceptability of the MASC methodology, whether generators may perceive any risks in being the first connection in GB using such an approach, and whether any incentives would be required to achieve agreement.
	Answer (e.i).4: There are a number of potential projects currently seeking connection within the SHE Transmission area which may be appropriate for the MASC project. Phase 1 of the project will identify a suitable location for deployment and with this, a suitable location for the first MASC deployment. If funding is awarded for the NIC MASC project, SHE Transmission will approach potential developers to discuss the modular approach. The developer and SHE Transmission will enter into a standard bilateral, commercial arrangement, and a construction agreement using National Grid's established protocols (CUSC). Note though, that NIC funding only covers the additional cost of deploying MASC for the first time. Therefore the developer is not expected to bear the additional costs of deployment, which will funded by NIC. There are further options available for deployment of the MASC equipment on one of SHE Transmission's planned refurbishment or reinforcement projects. This will also be considered during Phase 1 of the project. However, the use of a new generation site in a remote area, probably offers the highest potential to demonstrate the potential benefits of the MASC approach.
	Conclusion (e.i).4: This response clarifies that there has not yet been interaction

	between the project and renewable generators regarding this project. Hence it remains a concern that the acceptability of the approach has not been tested with such generators in view of the importance of such acceptability in identifying a trial site.
Sub-criterion (e.ii) - External funding (including level and security of external funding)	Challenge (e.ii).1: No external funding provided. This is linked to challenge (e.i).3, however an explanation as to whether the benefits of funding from external partners were considered and why this approach was rejected would be helpful.
	Answer (e.ii).1: The NIC project is seeking funding for the additional cost of first-time MASC deployment only. In agreeing to install an asset for a developer, SHE Transmission has a contractual obligation to deliver the connection within contracted timescales. In assessing the project's potential, it was considered that the use of external funding could pose a significant risk, rendering the connection date vulnerable through factors outwith SHE Transmission's direct control. Knowledge capture and dissemination activities will ensure that other network licensees can benefit from the knowledge gained in delivering the project.
	Conclusion (e.ii).1: SHE Transmission argues that external funding would introduce a risk to the connection date for the trial site. It is difficult to identify the circumstances under which such risks would crystallise.
Sub-criterion (e.iii)- Effectiveness of process for seeking and identifying new project partners and ideas	Challenge (e.iii).1: See challenge (e.i).2
	Answer (e.iii).1: See answer (e.i).1, (e.i).2, (e.i.).3 and (e.i.).4.
	Conclusion (e.iii).1: See response to challenge (e.i).2

2.7 Criterion (f): Relevance and timing

2.7.1 Key Statements

SHE Transmission's main claims in regard to this criterion are listed below:-

Significance of the project in overcoming current obstacles to a future low carbon economy

SHE Transmission states that the primary area of business planning which would benefit from the MASC project is the increasing requirement for TOs to provide network capacity for new renewable energy generation, which is being driven by the move to a low carbon electricity sector in GB. It recognises that the reduction of carbon emissions are not directly influenced by MASC. However the company argues that such reductions will be facilitated by the project, if it is successful.

The company goes on to argue that the benefits provided by MASC, such as shorter timescales between construction and deployment, a focus on off-site construction, and cost savings will help ensure that TOs are able to continue providing cost efficient connections for new renewable developments. This will help to reduce the overall cost of new generation projects which will play a part in maintaining the overall financial viability of these projects and deliver the objectives of the Carbon Plan.

Over the coming decade SHE Transmission expects to expand its transmission network significantly to facilitate the growth of renewable generation in the north of Scotland. If the method proves successful, SHE Transmission and other GB TOs can use the decision tool that it is planned to develop as part of the project to compare cost benefits between conventional builds and MASC builds for future substation projects.

Significance of the project in trialling new technologies that could have a major low carbon impact

The company remarks that there has been some limited use of some containerised components or temporary substations in GB and in other countries. It claims though that there have been several permanent, wholly modular substations successfully integrated into networks outside of GB. The success in other countries and engagement with the supply chain give SHE Transmission enough confidence to believe that this approach could be modified for application in the GB environment. As previously, the MASC methodology will not have a direct impact on carbon emissions but the company believes it will have an indirect effect by facilitating the speedy connection of renewable generation.

Significance of the project in demonstrating new system approaches that could have widespread application

As previously mentioned SHE Transmission has assumed, in assessing the potential benefits of the MASC methodology, that it could be deployed to 30% to 50% of the substations in the GB transmission network from now until 2050.

The applicability of the project to future business plans, regardless of uptake of LCTs (Low carbon Technologies)

In the absence of LCT's there would be likely to be a far lower demand for transmission substations. Nevertheless the approach described by SHE Transmission

would, if the project is successful, be applicable to a proportion of those that were constructed.

2.7.2 Challenges and Potential Shortfalls

Criterion (f): Relevance and timing;	
Sub-criterion (f.i) – **Significance of the project in**: (a) overcoming current obstacles to a future low carbon economy	Challenge (f.i.(a)).1: See challenges (a.i).1 and (a.i).2
	Answer (f.i.(a)).1: SHE Transmission considers there to be several current obstacles to the viability of new renewable projects and therefore, a future low carbon economy. These include: • Grid connection costs • Connection dates • Flexibility of network in response to generation development changes. The MASC project will reduce the cost and time associated with the delivering the connections required for these new developments. This will contribute to the overall financial viability of these projects and will help to ensure that these new projects progress to construction and help GB achieve its carbon targets. MASC also helps to create a network that is flexible, offering options in capacity increases/decreases within local generation plants. Also see answers (a.i).1 and (a.i).2
	Conclusion (f.i.(a)).1: See responses to challenges (a.i).1 and (a.i).2
(b) trialling new technologies that could have a major low carbon impact	Challenge (f.i.(b)).1: See challenges (a.i).1 and (a.i).2
	Answer (f.i.(b)).1: As stated previously the MASC project will incorporate a range of innovations to deliver the next generation of substations, which will facilitate the proliferation of renewable energy connections. It will not in itself trial new technologies that have a major low carbon impact. However, MASC will help ensure the continued viability of renewable projects which will help the country to achieve its carbon targets. Also see answers (a.i).1 and (a.i).2

	Conclusion (f.i.(b)).1: See responses to challenges (a.i).1 and (a.i).2
(c) demonstrating new system approaches that could have widespread application	Challenge (f.i.(c)).1: See challenges (a.iv).1, (a.iv).2, (a.iv).3, and (a.iv).4.
	Answer (f.i.(c)).1: SHE Transmission believes that the MASC approach has the potential to be widely adopted by both TOs and DNOs. TNEI market assessment of the need for future substation infrastructure indicates that SHE Transmission alone could have over 370 new projects by 2050. Inclusion of GB's other licensed network operators (both electricity transmission and distribution) increases the number of new projects between now and 2050 to over 1330. As indicated in the previous section it is anticipated that the MASC solution could be applicable in up to 50% of these new installations. Also see challenges (a.iv).1, (a.iv).2, (a.iv).3, and (a.iv).4.
	Conclusion (f.i.(c)).1: See responses to challenges (a.iv).1, (a.iv).2, (a.iv).3, and (a.iv).4.
Sub-criterion (f.ii) - The applicability of the project to future business plans, regardless of uptake of LCTs (Low carbon Technologies)	Challenge (f.ii).1: No specific challenges
	Answer (f.ii).1: No specific challenge given.
	Conclusion (f.ii).1: No further comments

2.8 Criterion (g): Demonstration of a robust methodology and that the project is ready to implement

2.8.1 Key Statements

SHE Transmission's main claims in regard to this criterion are listed below:-

Feasibility of project proposal

The company states that the MASC project is supported at all levels within SHE Transmission, via the established Innovation Steering Board, and that senior management will be involved in the development and operation of the project.

The project is scheduled to start on 01 January 2015. A project plan has been provided which provides evidence of expected timescales and key delivery deadlines.

Review of all risks, including customer impact, exceeding forecast costs and missing delivery date

SHE Transmission has provided a risk register and comments that MASC does not involve any interaction with, or possibility of supply interruptions to, end consumers and therefore there is no customer impact associated with the project

It also suggests that risk are managed in a number of ways including the following:-

- The submission has been reviewed by SHE Transmission's regulation and legal teams
- Key data has been checked by TNEI, the consultancy organisation appointed to support SHE Transmission
- The submission has been through several peer reviews and has been approved by SHE Transmission's Innovation Steering Board and Directors
- All SHE Transmission projects are subject to the company's governance and oversight processes
- Risk registers and mitigation measures are set in place to pro-actively manage the project and identify areas of concern.

If MASC is proven through the project, it can be deployed on an individual basis using the decision tool which will be created as part of the project's knowledge dissemination programme. This seems to imply that the tool will help to ensure that the methodology is only applied in appropriate cases.

Whether items within project budget provide value for money

The company states that estimated costs are based on a combination of historic experience of implementing and delivering innovation projects combined with information gathered during our engagement with the supply chain.

There are no plans to request contingency funding, other than indicated in the submission.

SHE Transmission mentions that projects are executed in such a way as to ensure careful management and expenditure. Issues are flagged at and in-between project review "gates" and a clearly defined escalation procedure is followed so that, in the event of concern the project may be halted and appropriate actions taken,

Project methodology

SHE Transmission claim that it has created a robust plan for the project's delivery, with all responsibilities clearly detailed and interdependencies identified.

Appropriateness of Successful Delivery Award Criteria (SDRC)

The Successful Delivery Reward Criteria have been derived and reviewed by SHE Transmission's Future Networks Management Team.

2.8.2 Challenges and Potential Shortfalls

Criterion (g): Demonstration of a robust methodology and that the project is ready to implement;	
Sub-criterion (g.i) - Feasibility of project proposal	Challenge (g.i).1: See challenges under criterion (a)
	Answer (g.i).1: The MASC project has support and backing at all levels within SHE Transmission and the project has been approved for NIC submission by SHE Transmission's established Innovation Steering Board. A detailed project plan has been included within the bid submission documents and a project manager has been appointed with sufficient resources to ensure the successful delivery of the project. The project will be in a position to start immediately after funding is confirmed. See also challenge answers under Section A and within Annex A.
	Conclusion (g.i).1: See responses to challenges under criterion (a)

Sub-criterion (g.ii) - All risks, including customer impact, exceeding forecast costs and missing delivery date	Challenge (g.ii).1: Whilst a risk register has been developed it is questionable whether it fully takes account of the challenges to the supply chain in providing solutions that meet the operational and financial ambitions of the MASC project within the required timescales.
	Answer (g.ii).1: MASC's risk register is an evolving document that will take into account any new risks identified through the life cycle of the project. Currently, the information received from various members of the supply chain has been consistent and we are confident enough to proceed with the project. A range of suppliers have successfully supplied modular equipment to various locations across the world. The existing NIA project is developing a functional specification for equipment which will be further developed before being used as a basis for first time deployment. At each stage of the project, measures are in place to ensure that the solution is valid, robust and cost-effective.
	Conclusion (g.ii).1: This recognises that the risk register will need to evolve.
	Challenge (g.ii).2: Several risks have been identified as of particular significance to the project as follows:- • External Engagement - Need to identify suitable site for first MASC application • External Engagement – National Grid as System Operator has leverage on the end solution • Technical - Short deployment timescales could mean reliance on European standard equipment • Technical - Off site commissioning or "Plug and Play' wiring solutions not satisfactory In view of their importance it would be helpful for SHE Transmission to clarify what steps are <u>currently</u> being taken to address these risks as this is not clear from the submission.
	Answer (g.ii).2: As stated in the answer to (g.ii).1, the existing NIA project seeks to develop a standardised, functional specification for modular equipment. This will include the addressing the

	challenges identified above. The deliverables from Phase 1 of the project have been structured to ensure that these challenges are addressed at an early stage in the project.
	Conclusion (g.ii).2: This response states that these risks will be dealt with under an existing NIA project but gives no indication of what is actually being done.
Sub-criterion (g.iii) - Whether items within project budget provide value for money	Challenge (g.iii).1: No specific challenges
	Answer (g.iii).1: No specific challenge given.
	Conclusion (g.iii).1: No further comments
Sub-criterion (g.iv) - Project methodology (including depth and robustness of project management plan)	Challenge (g.iv).1: No specific challenges
	Answer (g.iv).1: No specific challenge given.
	Conclusion (g.iv).1: No further comments
Sub-criterion (g.v) - Appropriateness of Successful Delivery Award Criteria (SDRC)	Challenge (g.v).1: The company has provided a list of SDRC's within its submission focused on a series of aspects of the project. The wording of these could sometimes be sharper in identifying the nature of the milestone that is being addressed. The evidence to be cited in achieving the criteria is entirely reports and papers. Implicit within these is progress with, for example, specification development and the establishment of the demonstration substation. However there may well be benefits in making such progress more explicit in the evidence required to demonstrate the achievement of the particular SDRC. Examples of such evidence could be the completion of the substation functional specification, agreement with a renewable generator that its connection will use the MASC methodology, procurement of plant and substation commissioning etc.
	Answer (g.v).1: At the consultants' recommendation, SDRCs have been reworded to clarify key outputs of the project. Please see

	Annex G for details.
	Conclusion (g.v).1: These changes are welcomed.

3 Response Summary

In this report the SHE Transmission application for Network Innovation Competition funding for the proposed MASC – modular approach to substation construction-project has been described. A number of challenges to the project have been raised in the context of the criteria by which such projects are assessed. SHE Transmission has responded to these challenges in the report. PPA Energy has also had the opportunity to attend two meetings between the company and the Expert Panel during both the panel and PPA Energy were able to address questions directly to SHE Transmission. In addition written questions have been sent to the company and responses received.

This process has eased concerns regarding a number of aspects of the project – in some cases entirely whilst in others partially. However there are some remaining concerns where it is still to be judged that the company has provided sufficient re-assurance. In particular:-

- The true level of innovation in the project – the company has put forward a number of proposed technical innovations and innovations in operational practices which it believes that the project would facilitate. However there remain some residual concerns as to whether this is sufficient.

- Level of cost savings – SHE Transmission has stated that the application of the MASC approach could lead to up to 20% savings in the cost of a substation. Whilst it is somewhat clearer how these savings have been estimated there are continuing doubts as to whether this could be sustained on a widespread basis.

- Scalability – it has not been convincingly argued that this approach could be scaled to the 275 or 400 kV voltage levels.

- Interaction with stakeholders (DNOs, manufacturers, renewable generators) – interaction with these stakeholders in the development of this proposal has been limited. The company has indicated that such interaction would form a large component of the early phases of the project and suggests plausible reasons for this. However additional interaction with such stakeholders during the preparation of the application could have provided additional confidence that it could achieve the desired results.

Annex A

(a.i).1 - Grid connection charges can form a significant cost element in new, renewable energy project developments. Any cost reduction relating to grid works will contribute to a project's overall financial viability. This should ensure that a greater proportion of renewable energy projects are financially viable and proceed to construction. As identified in the submission, there are a significant number of new substation projects planned for GB. Many of these projects are driven by the need to (i) provide connections for new, renewable developments (ii) provide grid capacity to deal with the impact of new developments and (iii) provide a network that can cope with future energy scenarios.

This requires TOs to deliver a large programme of projects within relatively short timescales. The additional flexibility inherent within the MASC solution will provide further options for TOs to deliver these projects. For example, reduced on-site construction time will give greater flexibility within fixed outage windows. MASC also offers greater adaptability to local network changes such as increases and decreases to plant capacity.

(a.iv).1 SHE Transmission asserts that cost savings of up to 20% will result from MASC, compared to costs of a conventional substation. The following table shows a breakdown of these costs, which are based on information received from the supply chain (and are therefore confidential).

Cost Elements	Based upon information in Figure 2 – AIS Substation	Based upon information in Figure 3 – MASC
Civil	xxxxx	xxxxx
Building	xxxxx	xxxxx
Transformer	xxxxx	xxxxx
Electrical HV	xxxxx	xxxxx
Project Management	xxxxx	xxxxx
33kV Equipment	xxxxx	xxxxx
Miscellaneous	xxxxx	xxxxx
Modular Equipment (inc Transformer)	xxxxx	xxxxx
Total	xxxxx	xxxxx

As stated within the main document the MASC approach and the move to off-site construction will reduce the cost of substation construction in a number of areas, including:

- Footprint and civil works: The use of a more modular design will signify reduced overall footprint and civil requirements as well as simplified planning consents. Early engagement with the supply chain has indicated that reductions in land requirements of up to 70% may be achievable; this will bring corresponding reductions in land costs. Further savings could also be realised in reduced drainage requirements, security costs, fencing and ground clearance.

- Off-site manufacture: The use of a modular approach will maximise the use of off-site manufacture and commissioning. This should significantly reduce the time required to install and commission the equipment on-site, this is particularly beneficial for projects situated in remote areas. Off-site manufacture brings production line efficiencies to a greater proportion of the substation construction and commissioning process.

- Reduced construction duration: As identified above, a modular approach will optimise the use of off-site manufacture and commissioning, signifying shorter on-site construction time requirements. Early engagement with the supply chain has indicated that site duration may be reduced by over 50%.

- Standard components: Current design practises for new substation projects generally result in a near "bespoke" design based around the use of a standard set of components. The ability to stock standard substation units creates efficiency and continuity in the manufacturing environment.

- Increased flexibility: Traditional substations are very "fixed" in nature; there are limited options for increasing or decreasing capacity without significant works. MASC's options for expansion and contraction drive additional cost savings.

- Transport and access costs: Modular equipment is designed to be easily transported and installed. This creates an advantage because construction is not weather dependent and civil works are reduced. The largely prefabricated nature of the equipment will result in fewer vehicle movements and deliveries to site.

It is recognised that there will be an increased cost for the procurement of the electrical equipment; this is largely due to the increased manufacturing time. The anticipated cost increase for the equipment is more than offset by the anticipated reductions in other areas.

(a.iv).2 The current NIA project is evaluating a range of innovations related to modularisation and civil engineering techniques; the specification at the end of the NIA project will inform our approach at Phase 1 of MASC. The following table describes some of the key innovations which may be used for the final build. However, the final model will be dependent on the outcomes of Phase 1 of the project. MASC will then demonstrate the chosen innovations in the field, providing knowledge and learning for the benefit of industry colleagues.

Innovation	Advantages
Modularisation of components	• The solution is much more compact with up to 70% reduction in land purchase requirements. • The substation components will be held in compact modules

	instead of being spread over large land areas or being contained in large-scale, agricultural-type buildings. • The modular approach is significant as the smaller layout and associated footprint should equate to lower land costs. • Lower land requirements will enable corresponding reductions in the cost mitigation actions to manage environmental impact compared to conventional models.
Screw pile foundations	• Easy to deploy, "turnkey" product. • Screw pile foundations are considered much more environmentally sound than the concrete foundations used with conventional substations. • This foundation type is recyclable, offers less disturbance to terrain and can easily be removed on decommission. • Screw pile foundations come in a range of solutions to suit the selected ground conditions. • As they are standardised, reusable products they offer better value for money than conventional concrete solutions.
In-factory installation of protection and control systems	• Protection and control installation and commissioning are historically time consuming and expensive. • In-factory installation and commissioning will help to reduce the overall timescales for installation of protection and control equipment. .

The innovations described are just some of the examples that may be included in the final specification. In addition, there is scope for temporary access roads, prefabricated bunding and rationalisation of auxiliary services. Information from the supply chain indicates that these solutions offer the potential to reduce costs compared with traditional solutions. That said, much of the cost saving comes from the reduced overall footprint, reduced construction time and reduced transport arrangements.

(a.iv).3 SHE Transmission believes that the MASC solution has the potential to reduce the overall timescales associated with the delivery of new substation infrastructure for the following reasons;

§ Design: once the basic, standardised solution is better understood and established, there will be reduced design requirements for subsequent projects.

§ Manufacture: given the modular nature of the substation and future aspirations for serial manufacture, factory production will be optimised and continuous. Programme efficiencies are expected as the modules will be purchased from a 'production line' as opposed to 'built to order'.

§ On-site time: As knowledge and confidence grows in the MASC solution the additional construction and commissioning contingencies will no longer be required.

The containerised nature of the MASC solution and its reduced environmental impact will help to reduce timescales associated with the planning and consenting process. It is believed that these factors will help to make any planning or consent application less contentious and enable a more timely decision to be reached. The stakeholder

engagement planned for Phase 1 of the project will explore these issues further and allow a range of views to be considered in the final design.

During Phase 1 of the project SHE Transmission will confirm the final specification and identify the equipment supplier for the trial deployment. This will include agreement on the manufacturing, construction and commissioning programme to ensure that the project is delivered in the committed timescales. The ability of a modular solution to reduce construction times will be a key piece of learning from the project.

(a.iv).5 We have already engaged with SHE Transmission's Environmental Management team to understand key concerns in substation construction amongst external stakeholders. These include (i) time spent on site (ii) visual appearance and (iii) transport arrangements. The MASC solution tangibly reduces these areas of concern and may avoid potential objections and challenges. Some of the issues MASC will address are:

- Substation overall size.
    - A modular approach will offer a much reduced overall footprint with up to 70% reduction in comparison to conventional substation land take.
- Land disruption and wildlife management.
    - The smaller footprint will clearly require less upheaval and disruption to land, with fewer excavations required and less need for concrete.
    - The potential use of alternative foundations is markedly better for the environment than the traditional use of concrete and can be removed easily on decommission.
    - The reduced land requirement will result in reduced disruption to shrubbery, trees, grasses and soil and therefore has less impact on local plant and animal species.
    - The off-site construction signifies substantial benefits in terms of fewer vehicle movements.
- Visual and acoustical nuisance.
    - There are various innovations which could allow the substation to be camouflaged or visually blended into their local environment.
    - Off-site manufacture reduces noise nuisance caused by heavy traffic and number of vehicle movements to site. Also, there is a reduced need for security fencing and lighting with reduced staff on site during the construction phase.
- Hydrology and drainage management.
    - Again, a smaller footprint and also innovative foundations are better for local water and hydrology issues. There is a decreased in the number of drainage solutions to be deployed.

The overall size reduction may help the substation project to fall into a "local development" rather than a "major development" within planning and consent legislation frameworks. This view is based on criteria for development categories in the Town and Country Planning (Hierarchy of Developments) (Scotland) Regulations 2009. Rules for consent and planning may vary from one local authority to another; for this reason, a period of stakeholder engagement is necessary in Phase 1.

(a.vi).3 SHE Transmission believes that MASC addresses several issues concerning future energy scenarios in terms of flexibility and optionality in infrastructure. A key point made in National Grid's Future Energy Scenarios relates to the lack of certainty around future energy markets:

“No one can be certain how the energy future will evolve and this uncertainty may continue for decades. Our Future Energy Scenarios represent transparent, holistic paths through that uncertain landscape to help Government, our customers and other stakeholders make informed decisions. These scenarios are not forecasts; they are predictions of the future that seek to discover plausible and credible conclusions for the future of energy.”

It is likely that the country’s future energy infrastructure will need to be flexible to accommodate changes concerning generation and demand developments. It is fair to assume that many developers will wish to extend or reduce capacity when replacing assets at the end of their life. MASC’s inherent capability for redeployment will better suit this environment than conventional substations.

If MASC is proved successful, it marks an industry-wide change to the way we view substation construction and deployment. MASC will bring a level of standardisation never before seen in substation infrastructure in GB, and accommodate flexibility in a way that conventional builds cannot. The creation of a strong supply chain will facilitate this flexibility, allowing new ways for equipment and components to work together if the benefits of MASC are proven. For this reason, the project is a necessary step to deliver improvements across the industry.

Annex G

(g.v).1 SHE Transmission concedes that the SDRCs can be rewritten to clarify project milestones and indicators of success. These are now as follows:

Criterion 9.1: Stakeholder engagement

A key milestone of MASC's success involves the outputs of engagement with key stakeholders groups, to potentially include:

- Internal contact with SHE Transmission business areas;
- External contact with other License holders:
- External dialogue with manufacturer and broader supply chain; and
- External stakeholders such planning and other statutory bodies.

Work undertaken within this criterion will seek to inform the development of the technical and functional aspects of the MASC substation.

Evidence: Completion of a stakeholder engagement programme with publication of key findings and their impact on MASC's functional specification requirements by 30th July 2015.

Criterion 9.2: MASC functional specification

The publication of the final, functional requirement document for the MASC project will require the identification of new equipment and associated requirements of operation and maintenance. The NIC funding will also support evaluation of new civil engineering practices and advances in aesthetics and environment that could factor into the final functional specification.

Evidence: The final functional specification will be published by 15th January 2016. This will contain identification of the key innovations that have been incorporated into the final technical specification.

Criterion 9.3: Knowledge capture from off-site construction

At this stage, MASC components will be manufactured and tested in a factory environment. This stage offers invaluable opportunities to evaluate individual components, protection and control systems. Comparison between MASC off-site construction and commission testing (in a clean, controlled environment) with conventional on-site construction processes will be collated.

Evidence: Completion of system testing at the factory stage and identification of costs savings will be completed by 31st of October 2016.

Criterion 9.4: On-site installation

At this stage, the substation will be transported to site, with essential on-site construction completed. Key learning from this stage will validate outputs from stakeholder engagement.

Evidence: The substation will be installed on-site with construction complete by 30th June 2017.

Criterion 9.5: Energisation

NIC funding will be used where appropriate to deliver validatory on-site re-testing and commissioning when the substation is installed and energised. Verification of on-site commissioning and energisation will also take place. This will be compared with the outputs from the factory commissioning tests.

Evidence: The energisation of the substation will be complete 29th September 2017.

Criterion 9.6: Operational Learning

The MASC solution is anticipated to challenge current operational and maintenance practices. Knowledge captured throughout a period of MASC operation will inform and validate key operational and maintenance theories.

Evidence: The MASC project team will publish a paper which summarises ways in which MASC solution elements challenge present day procedures. This paper will include mitigations against said challenges and highlight possible improvements. While the initial document will be available by 30 June 2018, this paper may be modified if new information is deemed relevant.

Criterion 9.7: MASC Performance Monitoring and Evaluation

Monitoring will be ongoing throughout the project's lifecycle. At this stage, valuable knowledge concerned with factory, transportation, installation, and operational monitoring will be collated.

Evidence: A programme of monitoring will be complete by 18th of December 2018.

Criterion 9.8: Project Closedown Report

At the end of the project, full evaluation and key learning points will be considered for inclusion in a comprehensive project closedown process. This will include learning gathered from knowledge events and the progress of the MASC substation during operation.

Evidence: A detailed closedown report will be delivered by the 28th June 2019.