# Electricity Network Innovation Competition Screening Submission Pro-forma

**Notes on completion**

Before completing this form, please refer to the Electricity Network Innovation Competition (NIC) Governance Document, which details all of the information that you are required to provide.

Please use Verdana size 10 font in your submission. The text entry areas are suggestions and the size of each text area can be altered if you need to provide more information in one section and less in another. In all cases the full-completed submission should not exceed **11 pages** in total.

**Ofgem will publish all the information contained within the Screening submission**.

**Funding Licensee**

SP Manweb Plc

**Network Licence Project Partners**

To be confirmed

**Funding Licensee area** *(or where the licensee does not operate in a specific area the geographic location(s) of the Project)*

SP Manweb

**Project title**

ANGLE - DC

**Project Summary**

*The Licensee must provide an approximate Project start and end date.*

The large volume of generation and demand requests present unprecedented challenges for the distribution network. Technical challenges include a combination of thermal limitations, voltage support problems and active control of power flows. Medium-voltage DC (MVDC) has been identified as a potential enabler to mitigate these issues. The most useful applications have been identified as:

- MVDC works as a valid alternative for distribution network reinforcements
- MVDC works within collector arrays for offshore renewable generation developments
- MVDC works as a scale down demonstration for potential transmission applications

Despite being identified as a useful technology, MVDC technology has not been used in any of the UK projects owing to its lack of delivery/operational experience and high cost. This proposal will deliver a novel reinforcement technique for the 33kV network. The technology has the potential to increase thermal capacity and provide instant voltage/power flow control by implementing a MVDC link across an existing 33kV circuit in SP Energy Networks' Manweb licence area.

This demonstration project will present the first DC operation of an existing AC distribution network circuit in the UK. The project is planned to start on April-2016 and complete on April 2020.

**Estimated Project funding**

*The Licensee must provide an approximate figure of the total cost of the project and the NIC funding it is applying for.*

| | | | |
|---|---|---|---|
| **Total cost of Project** | £15m | **NIC funding requested** | £13.5m |
| **Cross Sector Projects only: requested funding from Gas NIC or NIA?** | *If yes, please specify*<br>No | | |

## Problem(s)

*The Licensee must provide a narrative which explains the Problem(s) which the Project is seeking to address.*

Carbon budgets were introduced in the UK as part of the Climate Change Act 2008 to help the country reduce greenhouse gas emissions by at least 80% by 2050. As a consequence the electricity system is now facing a period of uncertainty where policy signals are driving for new lower carbon sources and uses of electricity. Different forms of low carbon generation such as photovoltaic cells, onshore wind and biomass plants, or loads such as electric vehicles and heat pumps will place very different demands on the network. A range of new network reinforcement solutions will be required to address these challenges.

Distribution networks are facing extensive reinforcement of the 33kV network, due to the increasing levels of distributed generation. Distributed generation, embedded at LV, 11kV and 33kV has in many areas exceeded local minimum demand, causing reverse power flows through the primary networks and triggering reinforcement to manage thermal, voltage and fault level constraints.

The North Wales network in SP Energy Networks' Manweb license area is symptomatic of a network under stress due to high levels of renewable generation connections and load growth. Currently the penetration of distributed generation is high and this is anticipated to increase significantly during RIIO-ED1. Demand is also anticipated to increase in the area significantly over the next 10 years due to various regeneration and development projects.

Conventional reinforcement alternatives for this type of problem include the addition of new assets and replacement of existing assets by larger units. This type of project typically involves significant costs and long lead times which result in delays to the connection of low-carbon generation.

The innovative medium-voltage DC reinforcement technique proposed in this project will introduce a power flow control device that will allow the full network capability to be utilised.

## Method(s)

*The Licensee must describe the Method(s) which are being demonstrated or developed. It must also outline how the Method(s) could solve the Problem. The type of Method should be identified where possible eg technical, commercial etc.*

It is proposed to implement an MVDC demonstration project that will maximise the utilisation of existing assets in order to address the problems associated with an increase of distributed generation/demand connections. This will involve the establishment of 33kV MVDC converter stations at each end of the circuit which will be operated at a DC voltage optimised for the existing insulation installed on the overhead line.

**MVDC Converters**

At each end of the DC link, a Voltage Source Converter (VSC) will be used to convert 50Hz AC to DC, and back again at the opposite end of the link. This is the same technology as is being used in HVDC links, but at present there are no commercially available product offerings at medium voltage. The converter stations will be able to respond rapidly to changes on the network, such as variations in generation/demand and network outages, by changing the power flow through the MVDC controlled circuit to reduce overloads and restore a compliant network voltage.

**DC Link Circuit**

The proposed link is constituted of a pair of 33kV circuits, covering a distance of

**Method(s) continued**

approximately 3km. The circuits are currently operated at 33kV and it is proposed to convert the operation of these existing circuits to DC. The circuits are on a combination of cable and overhead sections.

**Holistic Circuit Condition monitoring**

Circuit condition monitoring will form an important learning outcome of this demonstrator project. The project will demonstrate on-line partial discharge (PD) monitoring systems. These will be used to give an indication of PD based degradation and trend in time with other operating stresses which can influence PD including voltage ramp up/down, over voltages and ripple from power converters. The system will also trend electromagnetic interference detected from the converters. Data will be analysed and benchmarked to inform SP Energy Networks and other distribution network operators (DNOs) about the way in which distribution circuits age. Post-DC operation monitoring will allow for validation of theories about DC performance.

**AC Standby Circuit**

In order to de-risk the project and for reliability purposes, it is proposed that a new 33kV AC circuit will be installed in parallel with the DC link, in the event of a failure of the DC link. The cost of this bypass circuit has been included in the cost of the MVDC demonstration project. This will allow the MVDC VSC converter technology to be tested for a range of network and environmental operating conditions, whilst not adversely affecting the security of the network in any way.

**Funding commentary**

*The Licensee must provide a commentary on the accuracy of its funding estimate. If the Project has phases, the Licensee must identify the approximate cost of each phase. OFTOs should indicate potential bid costs expenses.*

The proposal team has carried out informal market engagement as part of an existing NIA project. The project costs have been developed using a bottom up approach, based on supplier responses and information available within the public domain. While it has been recognised that an accurate funding estimate is difficult in the absence of a detailed project specification at this stage, measures are planned to define this figure during the full proposal stage.

The project will be structured in the following phases:

- Phase 1: Design Stage: Identify system capacity benefits, detailed converter design and specification, development, analysis and testing, in the order of £1.8m
- Phase 2: Delivery Stage: Delivery, installation and commissioning of MVDC link, together with mitigation measures and monitoring devices: in the order of £12.2m
- Phase 3: Analysis, operation/maintenance, evaluation, in the order of £1m

A knowledge dissemination strategy will be developed during the full proposal development to ensure access to the learning arise for all interested parties.

**Specific Requirements** (please tick which of the specific requirements this project fulfils)

| | |
|---|---|
| A specific piece of new (ie unproven in GB) equipment (including control and/or communications systems and/or software) | ✓ |
| A specific novel arrangement or application of existing electricity transmission and/or distribution equipment (including control and communications systems software) | ✓ |
| A specific novel operational practice directly related to the operation of the electricity transmission and/or distribution system | ✓ |
| A specific novel commercial arrangement | |

**Accelerates the development of a low carbon energy sector & has the potential to deliver net financial benefits to existing and/or future Customers**

*The Licensee must demonstrate that the Solution has the potential to accelerate the development of the low carbon energy sector in GB and/or deliver wider environmental benefits to GB Customers. The Licensee must demonstrate the potential to deliver net financial benefits to existing and/or future Customers.*

*As stated in the Electricity NIC Governance Document, the Network Licensee must provide the following to demonstrate compliance with this criterion:*

*i. How the proposed Project will make a contribution to the Carbon Plan. In particular the Network Licensee should outline:*
- *What aspects of the Carbon Plan the Solution facilitates*
- *The contribution of the rollout of the Method across GB can have in facilitating these aspects of the Carbon Plan*
- *How the rollout of the proposed Method across GB will deliver the Solution more quickly than the current most efficient method in GB; and/or*

*ii. How the proposed Project could deliver environmental benefits to Customers; and*

*iii. The expected financial benefits the Project could deliver to Customers.*

**MVDC and the Carbon Plan**

The MVDC demonstration proposal aims to add a novel reinforcement technology to the toolbox of solutions used by SP Energy Networks and other DNOs to increase the network capacity in order to accommodate increasing low carbon technologies on the distribution network.

The government's Carbon Plan aims to deliver carbon emission cuts, and has identified the importance of distributed generation in meeting the targets in the Carbon Plan. This MVDC proposal directly facilitates the connection of additional distributed generation in a potentially shorter timescale than a conventional alternative reinforcement by providing a controlled power transfer capability between groups.

If successful MVDC technology offers the opportunity to realise additional generation headroom without extensive reinforcements with long delivery timescales. The potential for replication across the UK will be analysed during full proposal development.

**Environmental Benefit to Customers**

- Facilitating distributed generation

This project directly facilitates the connection of distributed generation by enabling the full network capacity to be used by providing controllability in the connection between two grid groups. Reducing the timescales and costs faced by renewable energy schemes connecting to the grid will help ensure the long term delivery of low carbon, environmentally responsible electricity to customers.

- Impact on Network Losses

An added benefit of the proposed MVDC technology is that it allows for the connection of two areas of network whilst maintaining electrical separation, thereby reducing network losses by control of flow through the MVDC link, and the support of network voltages on both sides.

Over the lifetime of the assets, this reduction in network losses is significant, and will help network operators deliver power to end customers as efficiently as possible.

- Enhanced thermal capability

In certain situations and, in particular for double-circuits, converting a circuit to DC could increase the thermal rating by over 20%. This would be achieved without any additional circuits.

**Accelerates the development of a low carbon energy sector & has the potential to deliver net financial benefits to existing and/or future Customers continued**

**Financial Benefit to Customers**

This project will de-risk MVDC technology while benefitting SP Manweb distribution network operations. The project will release additional generation headroom and reduce network losses by optimising power flows. The conversion of these benefits into financial terms will be investigated during the full proposal development.
Additionally, if successful the technology has the potential to facilitate capex savings in the offshore industry.

**Delivers value for money for electricity Customers**

*The Licensee must demonstrate that the Method(s) being trialled can derive benefits and resulting learning that can be attributed to or are applicable to the electricity transmission system/ to the electricity Distribution System.*

*As stated in the Electricity NIC Governance Document, the Network Licensee must provide the following to demonstrate compliance with this criterion:*

*i. What is the potential Direct Impact of the Project on a Network Licensee's electricity network or on the operations of the GB System Operator;*
*ii. Justification that the scale/ cost of the Project is appropriate in relation to the learning that is expected to be captured;*
*iii. The processes that will be employed to ensure that the Project is delivered at a competitive cost; and*
*iv. The expected proportion of the benefits which will accrue to the electricity Transmission System/to the electricity Distribution System as opposed to other parts of the energy supply chain.*

*Sub-criterion v (the internal systems, procedures and processes used by the Network Licensee to identify Project Participants and Project ideas) should be covered in the 'Project Partners and external resourcing/funding' section below.*

There is a great challenge for DNOs to connect an increasing amount of renewable generation. A simple calculation shows that around 20% additional thermal capacity can be released on existing double AC circuits by converting to DC.

Unlocking this capacity will create the following benefits:

- Demonstration of a reinforcement alternative for areas with combined voltage, thermal and fault level issues
- Reduced environmental impact by avoiding the construction of new circuits
- Accelerated network access

The number of anticipated replications at onshore networks at UK level will be further studied during the development of the full proposal.

The benefits of this demonstration project are not limited to DNOs and transmission owners (TOs) but, if successful, valuable data and learning will also be generated for the offshore industry. So far the lack of robust track record and associated risks have resulted in offshore developers not embracing this type of technology.

Direct MVDC connections could be a cost effective way to connect wind farms at medium offshore distances. This connection topology could eliminate the need for an offshore platform, which would lead to significant reductions in capital costs and a reduction to timescales for delivery at the expense of increasing losses. The 2014 Scottish offshore projects and interconnectors are spending £3.3bn on electrical infrastructure. Most of these existing projects are going to go ahead with conventional AC solutions, however this figure does indicate the potential scale of the offshore market in Scotland for MVDC, if the technology is matured and de-risked sufficiently for developers to consider it as a solution. A feasibility study by Scottish Enterprise indicates that if the same projects were to use direct to shore MVDC solutions, the reduction in capital costs could amount to up to £1.7bn.

**Delivers value for money for electricity Customers**

Given the above challenges and opportunities SP Energy Networks is in the process of engaging with various stakeholders to understand the appetite for this type of technology. DNOs and suppliers have been engaged and this will continue as part of future development of this project to ensure a competitive cost is realised.

**Demonstrates the Project generates knowledge that can be shared amongst all Network Licensees**

*The Licensee must explain the learning which it expects the Method(s) it is trialling to deliver. The Licensee must demonstrate that it has a robust methodology in place to capture the learning from the Trial(s).*

*As stated in the Electricity NIC Governance Document, the Network Licensee must provide the following to demonstrate compliance with this criterion:*

*i. What new knowledge is intended to be generated from completing the Project;*
*ii. What methodology will be used to capture results from the Project and how the Project's results will be disseminated to other Network Licensees; and*
*iii. Whether the Network Licensee wishes to conform to the default IPR arrangements as set out in Section B: Chapter 9. If the Network Licensee wishes to deviate from the default IPR arrangements it must outline the proposed arrangements, justify why the arrangements are more suitable than the default arrangements and justify how the new arrangements will deliver value for money for Customers.*

The project will generate new learning applicable for DNOs, TOs and offshore developers by demonstrating the first ever DC operation of a combined cable and overhead medium-voltage AC circuit.

All network operators will benefit from the learning generated by the project and will see their reinforcement options extended for areas of the network with double circuits. It is recognised that the cost of DC converters is still an important limitation. It is anticipated that DC conversion could become a competitive solution in areas which present a combination of the following, depending on the individual cases:

- Double circuits with no connection expectations
- Voltage issues
- Thermal constraints
- High fault level

The learning generated by the project will include:

- Control of a DC link under real AC distribution network conditions
- Operational experience of DC use of AC cables and overhead lines (OHLs)
- Demonstration of MVDC converters
- Availability data for MVDC converters
- Availability and ageing data for cable and OHL assets operated at DC

A full description of the knowledge dissemination strategy will be included in the full proposal which will incorporate:

- Circulation of reports to UK DNOs through the ENA Learning Portal
- SP Energy Networks will establish a project website with ongoing updates on project progress and findings and reports will be posted to facilitate access for all interested parties
- Presentations in SP Energy Networks events and appropriate conferences, forums etc. for all interested parties

The project will conform to the default IPR arrangements as laid in the applicable governance arrangements.

| **Please tick if the project conforms to the default IPR arrangements set out in the NIC Governance Document?** | ✓ |
|---|---|

*If the Licensee wishes to deviate from the default requirement for IPR then it must demonstrate how the learning will be disseminated to other Licensees and how value for money will be ensured. The Licensee must also outline the proposed alternative arrangements and justify why the arrangements are more suitable than the default arrangements.*

No anticipated deviations from standard IPR.

**How is the project innovative and with an unproven business case where the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness?**

*Demonstrate why the Licensee has not previously used this Solution (including where the Solution involves commercial arrangements) and why NIC funding is required to undertake it. This must include why the Licensee would not run the trial as part of its normal course of business and why the Solution is not Research.*

*As stated in the Electricity NIC Governance Document, the Network Licensee must provide the following to demonstrate compliance with this criterion:*

*i. Why the Project is innovative and has not been tried before;*
*ii. Why the Network Licensee will not fund such a Project as part of their business as usual activities;*
*iii. Why the Project can only be undertaken with the support of the NIC, including reference to the specific risks (e.g. commercial, technical, operational or regulatory) associated with the Project.*

Power electronics have experienced fast development and significant cost reduction in recent years. The improvements achieved in the semiconductor technologies have made of DC a realistic option for the medium voltage electricity industry. The projects seen so far have only reached the back-to-back level where DC is only materialised in the busbars within the converter station. The next foreseeable step for this technology is the realisation of DC across medium voltage circuits which has never been tried before in the UK. At this stage, SP Energy Networks is not aware of any commercial products outputting a medium DC voltage over 10kV.

The development of this technology in addition to the risk associated with the use of new equipment that has not been tested in a distribution network makes it impractical for DNOs to use this technology as part of the business-as-usual practice.

As in every innovation project a number of risks have been identified:

The main technical risk is damaging the existing AC circuit when converted for DC operation. Permanent monitoring of the DC circuit will be installed to understand the DC ageing mechanism of existing AC cables. In order to guarantee the security of supply to

**How is the project innovative and with an unproven business case where the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness? (Continued)**

the group, an AC cable will be laid in parallel to the DC circuit. This will be used as a contingency measure in case of unrecoverable damage to the existing circuit. The technical risks from the cable conversion will be explored further during full proposal development. If the risks are deemed too high at this stage SP Energy Networks will put the measures in place to stop further investment on the project.

Another challenge for this project is the development of the technology itself. A good response has been received by suppliers at this stage and there is a good level of confidence in the deliverability of the technology.

Construction risks include potential wayleaves issues.

**Project Partners and external resourcing / funding**

*The Funding Licensee should provide a description of the internal systems, procedures and processes used by the Funding Licensee to identify Project Participants and Project ideas.*

*The Licensee should provide details of any Project Partners, External Funders or Non-Network Licensees who will be actively involved in the Project and are prepared to devote time, resources and/or funding to the Project. If the Licensee has not identified any specific Project Partners, it should provide details of the type of Project Partners it wishes to attract to the Project.*

SP Energy Networks has been actively preparing and selecting the innovative proposals suitable for NIC regime. Medium voltage DC systems are included as a particular area of interest in SP Energy Network's innovation strategy.

The following measures have been undertaken to engage internal and external stakeholders including:

- ✓ Followed the latest development among licensees regarding their existing NIA/NIC projects by studying ENA portal and Ofgem announcements;
- ✓ Identified the relevant projects and arranged meeting/engagement to enable effective knowledge sharing within the industry;
- ✓ Published its intention to prepare 2015 NIC proposal to the industry and interested parties in 2014 LCNI conference in Aberdeen;
- ✓ Organised two internal stakeholders meetings to identify the business needs;
- ✓ SP Energy Networks further organised two internal R&D panels to shortlist the NIC proposal among over ten proposals each of which has both technology push and business pull

## Project Partners and external resourcing / funding continued

*The Funding Licensee should provide a description of the internal systems, procedures and processes used by the Funding Licensee to identify Project Participants and Project ideas.*

*The Licensee should provide details of any Project Partners, External Funders or Non-Network Licensees who will be actively involved in the Project and are prepared to devote time, resources and/or funding to the Project. If the Licensee has not identified any specific Project Partners, it should provide details of the type of Project Partners it wishes to attract to the Project.*

The project aims to demonstrate learning outcomes and build upon the following NIA and NIC projects:

1. Network Equilibrium (WPD)
2. HVDC Cable Condition Monitoring System (SPEN)
3. Investigation into the development of a MVDC Demonstration Project (SPEN)

The initial design stage may also draw on PMU data used to characterise network power flows for another innovation project in North Wales associated with the control of embedded generation.

SP Energy Networks is engaging with active market players who believe this project has the potential to unlock the currently unexplored MVDC market. Briefing notes have been circulated to the major market participants and direct conversations held to raise awareness of the project. Further conversations will clarify the contribution suppliers are willing to make for the development of the project.

A strong support has been received from the Welsh Assembly. They are very keen to progress the project to ensure the network does not become a bottleneck to connect further renewables and help achieve the government's carbon reduction targets.

Renewable developers have also expressed the interest in the project.

Engagement with other DNOs is ongoing at this stage.

## Derogations or exemptions

*The Licensee should outline if it considers that the Project will require any derogations, exemptions or changes to the regulatory arrangements.*

No derogations have been identified at this stage.

As a consequence of this project two loosely interconnected 33kV groups in North Wales may need to be merged. The group will contain the DC link and will be operated in compliance with P2/6.

## Customer impact

*The Licensee should outline any planned interaction with Customers or Customers' premises as part of the Project, and any other impacts (such as amended contractual or charging arrangements, or supply interruptions).*

The project will not involve any interaction with customers or work on customer's premises.

## Details of cross sector aspects

*The Licensee should complete this box only if this Project forms part of a larger cross sector Project that is seeking funding from multiple competitions (Electricity NIC and Gas NIC). The Licensee must explain about the Project it will be collaborating with, how it all fits together, and must also add a justification for the funding split.*

Not applicable.

| Any further detail the Licensee feels may support its submission |
| --- |
| This proposal demonstrates the step change of MVDC deployment on the UK distribution network. The innovation and risks/costs associated with the project delivery warrants the application. However, it has been noted that strong industrial support, significant learnings generated from this proposal and the robust management provide confidence and effective risk mitigations in delivering the project. |


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| --- |
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