Gas Network Innovation Competition
Screening Submission Pro-forma

Notes on completion

Before completing this form, please refer to the Gas Network Innovation Competition (NIC) Governance Document.
Please use the default font (Verdana size 10) in your submission, the text entry areas are predetermined and should not be changed. The full-completed submission should not exceed 10 pages in total.
Ofgem will publish all the information contained within the Screening submission.

Funding Licensee

National Grid Gas Distribution

Network Licence Project Partners

Northern Gas Networks, Keele University, ITM Power,
Health & Safety Laboratory, Progressive Energy

Funding Licensee area

Keele University, Staffordshire

Project title

HyDeploy

Project Summary

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

The objective is to demonstrate that natural gas containing levels of hydrogen beyond those in the GS(M)R specification can be distributed and utilised safely & efficiently in a representative section of the UK distribution network. Successful demonstration has the potential to facilitate 25TWh of decarbonised heat, and more by unlocking extensive hydrogen use as exemplified by the Leeds H21 project.

Problem: The UK has committed to substantial carbon savings; heat contributes to a third of its current emissions. Delivering low-carbon heat via hydrogen over the gas grid provides a customer-focused solution, but is limited by onerous UK limits.

Method: The first UK practical deployment of hydrogen onto a live gas network since the transition from town gas. Exploiting Keele University's gas network risk manages project delivery and enables a more ambitious trial than would otherwise be achievable. This 3 year project, starting April 2017, is based on the principle of survey, test & trial necessary to secure HSE exemption to GS(M)R and roll out the testing programme.

Solution: The project provides a body of practical, referenceable data which is an essential pre-requisite to enable wider deployment of hydrogen and therefore delivery of cost-effective, non-disruptive carbon savings to the customer.

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	8.1m	**NIC funding requested**	7.1m
Cross Sector Projects only: Requested funding from Electricity NIC, NIA or second tier LCN Fund?	*If yes, please specify* N/A		

Problem

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

The UK has committed to reduce greenhouse gas emissions to 80% of 1990 levels by 2050. Heat contributes a third of the UK's carbon emissions. The Carbon Plan specifically identifies the need for low carbon heat in order to meet these targets. Whilst progress is being made to decarbonize electricity, decarbonising heat has proved challenging.

The UK has a world class gas grid and gas dominates the UK heat supply curve, heating 82% of the UK's buildings and providing most of the UK's industrial heat. Heat demand is highly variable, NG(2012) and compared with alternatives such as heat pumps, a low carbon gas is readily capable of meeting peak heat. It exploits existing network assets cost effectively and customers do not require disruptive and expensive changes in their homes.

Gas can be decarbonised by (a) using bio- rather than fossil- carbon, ie biomethane, already increasingly & successfully deployed in the UK, and (b) removing the carbon entirely by using hydrogen as a vector. The latter is identified as important by DECC (2013) but recognises further development activity is required. Key to this is establishing the practical feasibility of delivering it, initially as a natural gas blend, across the network and utilising it in real appliances.

Prior to the conversion to North Sea gas, the network distributed town gas with 40-60% hydrogen. Subsequently the hydrogen limit was set to 0.1% because the gas composition did not include hydrogen. There has been substantial study work undertaken supporting the theory of hydrogen injection into the grid, but limited practical experience. In Germany up to a 10% natural gas blend is permitted, and a few projects have undertaken hydrogen injection. Due to the current regulated limits, there has been no UK experience.

To pursue this decarbonisation route, the UK needs to undertake practical hydrogen injection to establish that it is feasible and determine the appropriate level of blending on current networks and in appliances. This requires carefully executed, safely managed, real deployment, to demonstrate that the practical, regulatory and operational barriers can be successfully addressed.

Method(s)

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

The Project is a foundational study based on practical deployment, which can be referenced by all GDNs & stakeholders in pursuing decarbonisation of the gas distribution system using hydrogen. It builds on international work such as GERG HIPS(2015), and existing NIA activities being undertaken by NGN and NG, as well as best practice from other NIC projects.

Keele University has a closed, private gas network, which it is exploiting as a 'living laboratory' under its Smart Energy Network Demonstrator (SEND). It comprises a network and appliances typical of UK gas distribution systems, domestic & commercial users including a CHP, but under the control of the University as a local, licenced supplier. It is an ideal host for the first UK step towards hydrogen deployment, risk managing the delivery of the project & enabling a more ambitious trial than would otherwise be achievable. The Method comprises 3 phases: **PHASE 1: Engagement.** Using best practice from SGN's Oban NIC, the project will engage with all local customers, as on a public network; but with the confidence of 100% access.

Method(s) continued

Network and appliance survey. Every appliance and installation will be baseline surveyed and tested locally on NG-H2 blends, including supporting offline tests. Where required, appliances will be replaced. The network will be surveyed, modelled & operational procedures for leak detection and network management processes established including metering. **Secure GS(M)R exemption**. The Project has already engaged with HSE; based on the data and QRA, an exemption to GS(M)R will be sought for a staged increase from 0.1% to 10%, & potentially up to 20% (still within GS(M)R Wobbe limits), subject to meeting conditions-precedent relating to assessed risk. **PHASE 2: Installation of onsite hydrogen production, injection plant & network monitoring**. Equipment will be capable of delivering up to 20% hydrogen, with network sample points and compositional, pressure & flow analysis facilities installed. **PHASE 3: Hydrogen injection trials.** An 18 month programme will be undertaken to confirm, understand and document the operational behaviour of the network and appliances, validating network modelling and developing best practice for network management. **Next steps & wider dissemination**. NG and NGN are liaising with stakeholders within both GDNs to identify suitable public networks for a subsequent project, based on the best practice developed in this programme. The Project results will also be disseminated to ensure all stakeholders can benefit from this work.

Funding commentary

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

The cost of project phases

• Phase 1 (12mth): Activities required to secure exemption including customer engagement, baseline survey, provision for appliance/network element replacement as required, experimental data, delivery of safety case & engagement with HSE: £3.4m

• Phase 2 (6mth): Construction of equipment on network for hydrogen production, injection and for extensive sampling on the network £3.0m

• Phase 3 (18mth): Testing phase and analysis, including continued stakeholder engagement & knowledge dissemination £1.7m

Indication of cost estimate certainty

• Hydrogen production and grid injection equipment has been costed by expert project partners with extensive experience, accuracy of +/-10%

• Assessment of sampling equipment has an accuracy of +/-20%

• Labour required for experimental activities has an accuracy of +/-20%

Potential bid costs of £175,000, including further work to de-risk the project

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 gas transmission or/and distribution equipment (including control and communications systems software)	✓
A specific novel operational practice directly related to the operation of the gas transportation 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.

The Carbon Plan identifies the need to *'deliver between 83-165TWh of low carbon heat'* by 2030, but the RHI (Dom & Non-Dom) delivered less than 4.5TWh in 2015 and DECC (2016) anticipates *'that by 2020/21, the RHI could deliver 23.7TWh of renewable heat'*. A step change is required to meet low carbon heat commitments.

The Carbon Plan Executive Summary states that *'the oil and gas used to drive cars, heat buildings and power industry will, in large part, need to be replaced by electricity, sustainable bioenergy, or hydrogen'*. It identifies the consumer and network challenges associated with adoption of non-gas low carbon solutions such as biomass combustion or heat pumps (High capital costs, time to install, heating replacement - a 'distress purchase' and added strain on the electricity grid). Peak heat requires an upturn of 500% from the lowest to highest day of the year and 100% from the lowest to highest hour. Decarbonising the gas grid addresses these issues. DECC(2012) identifies that *'Two low carbon fuels could be deployed through a national grid network, similar to how natural gas is delivered today: biomethane and hydrogen'*. It recognises that *'In the near term, relatively small quantities of hydrogen could also be injected into the gas grid to enrich natural gas and reduce carbon emissions from conventional gas-fired boilers'* and that *'it may also be possible to repurpose the existing low-pressure gas distribution grid to transport hydrogen at low pressures, which could be used in modified gas boilers and hobs, and in building-level fuel cells.'* It identifies that *'More evidence is needed on whether hydrogen-based approaches hold practical promise for the UK'*, re-echoed in DECC(2013) the *'need to focus particular effort will be on heat storage and on hydrogen'*. This is exactly the purpose of this project.

The UK gas distribution network alone provides around 500TWh. Establishing practical injection of hydrogen at between 10-20% molar fraction into this would deliver between 16-36TWh of decarbonised fuel – equivalent to the entire RHI scheme in 2021 forecast. Further, it would unlock progress on a more substantial hydrogen roadmap, as exemplified by NGN's H21 Programme, which could see complete decarbonisation of some or all of the gas grid. Exploiting Keele's network for this first UK trial enables safely trialling a higher blend than might be expected on a public network in the first instance, delivering the Solution more quickly.

This Solution enables gas customers to play their part in decarbonisation without disruptive and expensive demand-side changes. To deliver 36TWhr of heat via ground source heat pumps costs an additional £5,800m pa compared with conventional gas, DECC(2016) data. Low carbon hydrogen can be obtained from a variety of sources. 36TWhr from electrolysis costs £0-£2,500m pa depending on cost of electricity (wholesale, or curtailed wind/solar); using waste biomass via gasification/shift, i.e BioSNG without final methanation, costs £0-£2,100m pa, NIC(2015); and using SMR plus CCS costs £1,400m pa, TVU(2015). This represents savings of £3,300-£5,800m pa or £140-£240 pa per gas connected household compared with ground source heat pumps, excluding the costs of avoided electricity network reinforcement - £12-20,000m, Delta(2012), and additional 40-50GWe generation capacity, as well as the estimated £8,000m gas network decommissioning costs associated with non-gas solutions.

Delivers value for money for gas 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 gas transportation system.

The wider customer benefits of unlocking hydrogen as a decarbonisation vector are outlined above. The strategy of exploiting Keele's network, rather than a public network offers good value to gas customers because it substantially de-risks the project, delivering understanding in a well controlled environment prior to roll out on a public network.

It leverages Keele's SEND project, supported financially by BIS & the European Regional Development Fund to deliver good value. Key partners are contributing 10% towards the programme costs. NG and NGN undertake that equipment developed (H2 production, injection, & analytical facilities) will be available for follow on projects on a public network as part of wider roll out. In the unlikely event that further roll out were not possible, the electrolyser provider will provide a buy-back of its unit. NG engaged with a number of partners for key roles, making selections based on experience and competiveness of commercial offering. The project will be managed such that costs are controlled and value delivered. Compared with the benefits the route unlocks £3,300-5,800m pa savings, and the considerable existing investment cost in theoretical studies to date, the request for £7.1m from NIC for actual UK deployment offers good value.

This programme is focused on enabling the GDNs themselves to understand and develop the capabilities of their network as a practical & safe means to deliver low carbon, flexible heat. The specific learning from the project is therefore directly attributable to the gas transportation system.

Demonstrates the Project generates knowledge that can be shared amongst all 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).

Knowledge generated. The purpose of the project is to provide seminal unique & referenceable data for all GDNs and other stakeholders looking to produce, deliver or utilise hydrogen using the gas grid. The knowledge generated will be from a set of existing appliances operating on a hydrogen blend delivered through a live network, with the practical realities this entails. The specific learning comprises appliance operation including a CHP, gas mixing into and throughout the network, pipeline and jointing materials issues, leak detection & network maintenance, metering & associated commercial issues, and the principles of securing a H2 GS(M)R exemption from HSE.

Knowledge dissemination is integral to the project execution. The programme is collaborative between 2 GDNs, both of whom have a strategic interest in hydrogen deployment. In addition to the LCNI Conference, arising knowledge will be shared with the other UK GDNs through a series of specific seminars organised by NG and NGN to share detailed technical information on a peer-to-peer basis. Project members are participants in existing international programmes such as the GERG HIPS, an ideal forum for mutual knowledge sharing along with other conferences. Keele is committed to knowledge transfer through its SEND programme and as an academic partner, it will produce high quality peer-reviewed academic papers. The adoption of hydrogen requires engagement with customers & the wider public. This will be initiated with the Keele University community, prior to any activity on the network, building on Oban best practice, including drop-in events, a media campaign & a dedicated website This will then be rolled out nationally with a campaign similar to NG's recent 'Future of Gas'.

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.

The purpose of this project is provide insights and data for all Network Licensees and wider stakeholders, and therefore the Network Licensees confirm that they will conform to the default IPR arrangements.

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.

Physical injection of hydrogen blended with natural gas into the network never has been undertaken in UK, although there have been numerous theoretical studies. Until 1967, the UK energy carrier was town gas (a blend of H2 and CO). With the discovery of North Sea Gas (NSG), the grid was progressively converted over 10 years. Extensive technical work by Dutton established the impact on networks and appliances of a range of gas compositions through 'interchangeability' diagrams, but due to the lack of naturally occurring hydrogen in NSG, these were simplified to exclude its effects, setting the regulatory limit to just 0.1%. This has left the UK substantially behind countries such as Germany & Holland who have exploited much higher blends.

The barriers this project will address relate entirely to the ability of a UK gas network to secure an appropriate hydrogen exemption from HSE, and to undertake operational trials of Hydrogen-Natural Gas blends. There is no financial benefit to the network, to undertake such a programme, and no reason it should do that under business as usual operation. The risks this programme seeks to address are: Technical & Operational - operation of appliances safely on a blend, safe operation of the network including network flows, pipeline integrity, network maintenance and leak detection; Commercial - metering of hydrogen and appropriate billing regimes; and Regulatory – securing a derogation for the initial network, & establishing best practice for subsequent derogation on a public network. None of these risks would need to be addressed if the GDNs were to continue to operate the network using natural gas. The rationale for the project is to enable an alternative, low cost & non-disruptive decarbonisation solution for the customer and for the UK to meet its carbon commitments.

Project Partners and external resourcing/funding

The Licensee must provide evidence of how Project Partners have been identified and selected, including details of the process that has been followed and the rationale for selecting participants and ideas for the Project.

The Licensee should provide details of any Project Partners 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.

National Grid Gas Distribution is the Funding Licensee & project sponsor. Its innovation team undertakes an internal process to identify both new project ideas and participants. Through this process it identified the need to clear barriers to facilitate hydrogen adoption. It is currently undertaking NIC gas projects.

Northern Gas Networks is a collaborating GDN who have been leading flagship hydrogen innovation programmes, including H21 Leeds project, as well as an existing collaborative NIA with NG on hydrogen injection undertaking the enabling works which facilitates this project.

Keele University: Site sponsor, host network and academic collaborator. Keele provides a unique site which both de-risks and provides unprecedented opportunity for network learning under their SEND programme.

ITM Power: provider of electrolysis unit and sourcing of grid injection facilities. They are uniquely experienced in hydrogen grid injection based on their work in Germany on two projects (RWE's Power-to-Gas installation in North Rhine-Westphalia, and the Thüga project in Frankfurt), where their equipment is current injecting hydrogen into the network.

Health and Safety Laboratory (HSL): One of the UK's foremost health and safety experimental research establishments. They have particular understanding of the issues that HSE need to see addressed in this field, and will plan and oversee the experimental programme at Keele and in their own labs. Their work includes analysis and synthesis of the results from the testing and trial programme

Progressive Energy: Project management, planning and overall programme co-ordination. Selected based on proven NIC project management.

In addition to the core partners, the project is supported by key industry experts:

KIWA Gastech will undertake practical survey, test and trial work onsite, building on their experience of such work, in particular at Oban.

Dave Lander Consulting is a well-respected specialist in the field, and will develop the safety case and manage the QRA for submission to the HSE to secure the exemption, based on the survey and test programme.

Otto Simon (OSL) provides engineering services for projects, particularly more innovative systems in the process engineering sector and has a track record of delivery in NIC projects. Their role is construction management of the new facilities and engineering design/management resource.

British Gas is a project participant with a longstanding interest in hydrogen deployment. They provide a commercial perspective relating to issues of hydrogen supply into public networks.

In terms of communications/media/publishing resource, NG has experience of a number of providers who can undertake this for the project.

Derogations or exemptions

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

In order for this trial to proceed an exemption from the combustion requirements of Schedule 3 of the GS(M)R will be required, specifically a derogation to the hydrogen limit of 0.1%. No exemption is required for the Wobbe Number which will remain within limits.

Exemption from any requirement imposed by the GS(M)R are provided for by Regulation 11 of the GS(M)R. Essentially the HSE shall not grant an exemption "unless it is satisfied that the health and safety of persons likely to be affected by the exemption will not be prejudiced in consequence of it". Exemptions may be granted subject to conditions and a limit in time and may be revoked at any time by a certificate in writing.

The HSE decision, will be based on no additional risk or/and as low as reasonably practicable. This will be informed by the baseline survey work, extensive test data and existing literature, and corresponding QRA.

Customer impact

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

This programme necessarily has an impact on gas customers on the Keele network. All interactions with customers will build on Oban Project experience and best practice for engagement. An extensive engagement plan will be put in place with stakeholders and customers. This will include provision of information on the principles and benefits of the project, and the provision of communication channels for discussion and feedback to inform and assist delivery.

The hydrogen blend will only be trialled on the network if HSE are satisfied that it is safe to do so and that they provide an exemption. This will only be granted if the evidence base generated and presented in the safety case and QRA supports it.
Benefits to customers will be free testing and safety check of appliances and their installation as well as free replacement of faulty appliances.

Keele University is a licensed supplier, delivering gas to its customers. In executing the programme it will ensure that its customers pay only for the natural gas delivered, and the energy associated with the additional hydrogen provided in the project will be provided to them at no additional cost.

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 (Gas NIC, Electricity NIC or LCN Fund). The Licensee should explain about the Project it will be collaborating with, how it all fits together, and must add a justification for the funding split.
Not applicable. This is a Gas NIC only Project.

Any further details the Licensee feels would add to the submission
This Project forms part of a wider roadmap towards deployment of Hydrogen on the UK gas network. Upstream it builds on the existing NGN/NG NIA (2016) "Hydrogen feasibility study" which is undertaking enabling activities for this NIC. The current NG/NGN NIA called Review of FWACV Billing Regime has informed this ISP and the subsequent NGN led collaborative NIC submission called Future Billing Methodology will be built into this project, if both are successful. It also draws on and is integrated within the vision created by the NGN NIA (2015) H21 Project, Feasibility into the conversion of the Leeds City to 100% hydrogen which considers a more wide-reaching conversion. Building on this NIC programme itself, further deployment of hydrogen on the wider distribution network will exploit the learning, and the assets developed. <u>References</u> DECC (2012) "The Future of Heating: A strategic framework for low carbon heat in the UK. 2012", NG (2012) Pathways for decarbonising heat, Redpoint & Baringa September 2012 DELTA (2012) "2050 Pathways for Domestic Heat" Delta EE, October 2012 DECC (2013) "The Future of Heating: Meeting the challenge, March 2013" GERG HIPS (2014) The European Gas Research Group,"Hydrogen in Pipeline Systems" TVU(2015) "Industrial CCS on Teesside" The Teesside Collective BioSNG NIC (2015) BioSNG Demonstration Project DECC (2016) "The Renewable Heat Incentive – A reformed and refocussed scheme"
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