Proposal for
Provision of Hydrogen end User Skills and Standards for Heat Supporting Research Evidence.

Department for Business, Energy & Industrials Strategy

Customer Reference: 5045/04/2021
DNV doc No: 126836
Date of first issue: 2021-09-24
Date of this revision: 2021-09-24

Customer Details

Customer Name:	Department for Business, Energy & Industrials Strategy
Customer Reference:	5045/04/2021
Contact Person:	[This information has been redacted]

DNV Company Details

DNV Legal Entity:	DNV Energy Systems
DNV Address:	Holywell Park, Ashby Road, Loughborough. LE11 3GR
DNV doc. No. :	126836

About this document

Proposal Title:	Provision of Hydrogen end User Skills and Standards for Heat Supporting Research Evidence.
Date of first issue:	2021-09-24
Date of this revision:	2021-09-24
Validity of proposal:	3 months from date of issue
Terms and Conditions:	See Section 8, Contractual

Confidentiality

This proposal contains information that is business sensitive to DNV. No part of the proposal or information received during the proposal process may be used, duplicated or disclosed for any other purpose. Any such use of DNV's information is regarded as an infringement of DNV intellectual property rights.

for DNV Energy Systems

Prepared by:

[This information has been redacted]

Approved by:

[This information has been redacted]

Table of contents

1 INTRODUCTION

This proposal has been prepared in response to the ITT from the Department of Business, Energy & Industry Strategy for experimental studies on hydrogen safety. DNV has extensive experience, spanning several decades, in conducting hazards research, both in terms of experiments and modelling. We have operated the unique Spadeadam Research and Testing facility for over 40 years, conducting benchmark large scale experimental research for many hazards related to the Oil and Gas industry. This proposal takes advantage of the existing facilities at Spadeadam and the experience of personnel in conducting hazardous experimental studies efficiently and safely. DNV would like to offer a proposal for all 5 Lots, this document provides an overview of DNV experiences, project team and contract aspects. The additional individual Lot documentation will provide the methodology, schedule, pricing and delivery aspects for the individual Lots 1- 5.

2 SKILLS & EXPERIENCE

DNV Spadeadam Research and Testing has its origins in British Gas Research and Development. The first experimental studies at the site were carried out in 1977 and it has been in continuous operation since that date. In the early years of operation of the site, British Gas Research and Development operated several smaller test sites, however all the experimental work eventually migrated to the Spadeadam facility. The infrastructure available for experimental research has grown over the decades and now, as part of DNV, it operates as a commercial research and testing facility supported by the extensive technical experience within DNV.

Because of its history and the continuing relationship with natural gas networks within the UK, DNV has carried out much of the UK experimental research related to the potential hazards of natural gas transmission, distribution and utilisation. The motivating factors for the studies included:

- The development and validation of models for the consequences and risks associated with accidental natural gas releases.
- Provision of information to guide emergency response by UK gas networks when a gas release is reported.
- Support provided for the UK gas networks in the investigation of gas explosion incidents. UK networks have a regulatory responsibility to investigate all natural gas explosion incidents under the Gas Safety (Management) Regulations 1996.

Over the last fifteen years or so, several experimental research projects have been carried out to extend this understanding to the hazards related to hydrogen, both on its own and mixed with natural gas.

Further details of this experience and its relevance to the current research proposal are given in the following sections.

2.1 Consequence and Risk Modelling

DNV has developed models to estimate the consequences of hydrocarbon loss of containment events ranging from industrial scenarios through to domestic situations. The models have been developed and validated using experimental data, mostly obtained from tests conducted at Spadeadam or at earlier, smaller test sites operated by British Gas Research & Development.

The models cover aspects such as fluid outflow, dispersion, liquid spread, fires and explosions. Whilst they can be used individually in consequence analysis, DNV has also integrated them into risk models that incorporate information on the likelihood of events to allow the risks associated with oil and gas operations to be understood. This has included the development of risk models for natural gas distribution and utilisation.

The relevance for the current proposal is that, though the scope of work is for experimental studies, the experience and capability related to modelling is important in both the design of the experiments and the interpretation of the data obtained from the studies. Of particular importance is the modelling of gas dispersion and build up within confined volumes typical of domestic properties. DNV has modelling capability in both in-house phenomenological models and Computational Fluid Dynamics (CFD) and also collaborates with other

organisations in relation to the research. Work has already been carried out on the extension of the in-house single volume gas build-up model to hydrogen mixtures (see Section 2.3.1).

2.2 Incident Investigation

As already indicated, DNV incorporates groups, including Spadeadam Testing and Research, that can trace their heritage from British Gas Research and Development. As a result, over a period of more than four decades, DNV has provided technical support to UK gas distribution networks in relation to the investigation of gas explosion incidents.

The support is provided at the request of the networks and is generally for the more severe incidents where establishing the cause of the incident may require more detailed and complex investigation. A 24 hour call out service is operated to allow quick response should the support be needed. DNV also provides advice to the networks in the case of litigation or prosecution. Calls for this type of support occur on average about once a month.

DNV's ability to support technical investigation of gas explosion incidents is based on extensive experimental studies into gas release, dispersion and build up and explosions. This knowledge of natural gas behaviour and its relevance to incidents was originally published as a book[1] that has since been periodically updated and maintained as an internal reference document.

As a consequence, DNV has extensive experience of the types of releases that can lead to severe natural gas explosions, both from a research perspective and experience with actual incidents. This experience will assist in both optimising the test programme and interpretation of the data.

2.3 Hydrogen Research Examples

2.3.1 DNV HyStreet

DNV has invested in constructing DNV HyStreet which comprises of 3 research houses to undertake vital research on hydrogen and comparisons with natural gas. The H21 project and Hy4Heat projects have recently utilised the research houses. They are currently fitted with two hydrogen ready boilers.

[1] The investigation and control of gas explosions in buildings and heating plant, RJ Harris, E&FN Spon, 1983.

Figure 1: DNV Hystreet

2.3.2 NaturalHy

NaturalHy was a programme of research related to blended mixtures of hydrogen and natural gas. Legacy DNV led the project and the large scale research was conducted at DNV Spadeadam (Advantica as it was then). The programme involved work packages performing experiments related to both domestic and industrial gas build up and explosion. The programme also featured experiments where high pressure (~70 bar) mixtures were released in horizontal jets and as pipeline failures (6" N.B. ruptures) to ascertain the thermal and overpressure hazards.

2.3.3 Hydrogen Fuel Filling Station

DNV was commissioned, at the Spadeadam Testing and Research Centre in the UK, to perform a research programme related to the safety of hydrogen vehicle refuelling stations. The results of the experiments and associated research were published at a hydrogen safety conference[2] and presented at a Fire and Blast Information Group (FABIG) discussion meeting in 2005. The research was commissioned by Osaka Gas in 2004 as part of the Japanese National Hydrogen Project and involved three phases studying: idealised explosions, hydrogen accumulation and explosions in a realistic full scale model of a refuelling station. The project included model validation using the experimental data.

2.3.4 H21 Phase 1b

Migration, Tracking and Accumulation Studies

A set of research houses has been built on the Spadeadam Research and Testing site. These houses were built in 2018 for the purposes of the Ofgem and Gas Distribution Network (GDN) led H21 project. This project is concerned with the comparative risk of hydrogen distribution versus natural gas distribution and the houses were built by DNV to

[2] Takumi Tanaka, Takayuki Azuma, Evans J.A., Cronin P.M, Johnson D.M., Cleaver R.P. Study of Hydrogen Releases at Filling Stations, International Conference on Hydrogen Safety, 9th September 2005

allow the potential for hydrogen (or natural gas) accumulation to be assessed for a wide range of gas network leakage, stopping short of any leakage due to pipework, appliances or meters downstream of the network's emergency control valve at each property.

Ignition Potential Studies

A series of ignition potential experiments are underway at Spadeadam on the H21 project. The experiments are designed to give some qualitative information on the likelihood of a specific piece of equipment igniting hydrogen / air mixtures of different concentrations. Equipment for testing has been chosen for relevance to network operations (e.g. excavations and emergency call outs) but does include some domestic circuitry. The work is designed to build on DNV's extensive experience of ignition potential testing with natural gas.

2.3.5 H21 Phase 2a and Phase2b

DNV Spadeadam is currently in the process of delivering the Master Test Plan of H21 Phase 2a project. The project has involved the construction of a hydrogen distribution system, labelled a 'Microgrid'. This Microgrid consists of an extensive array of polyethylene pipes conveying hydrogen through all pressure tier and diameters from high pressure (50barg in the storage array) down to low pressure (30mbar) through a series of governors and network assets.

The test programme involves around 100 different operational tasks to demonstrate the safe operation of a hydrogen network, the tasks are grouped into categories, all of which involve creating hydrogen specific procedures and carrying them out on the live network:

- Emergency Response
- Finding Leaks
- Accessing Leaks
- Isolation and Flow Stopping
- Live Gas Operations
- Purging
- Flow Modelling

2.3.6 Hydrogen Transmission Fires

In 2008, DNV conducted a series of pipeline fire experiments for a hydrogen pipeline operator in the US. The experiments involved high pressure releases of hydrogen from hole sizes ranging from 10 mm up to 150 mm in diameter. The experiments aimed to provide data on the outflow conditions, thermal radiation and overpressure hazard distance of such releases. The results of the experiments were presented at the International Pipeline Conference in 2010[3].

2.3.7 National Grid FutureGrid Project.

DNV are currently engaged with National Grid at the experimental design stages for the FutureGrid project: set to build and operate a hydrogen transmission system at Spadeadam with an array of existing assets brought to Spadeadam to undergo hydrogen service

[3] Acton, M.R., Allason, D., Creitz, L.W., Lowesmith, B.J. Large scale experiments to study hydrogen pipeline fires, IPC2010-31391. in: International Pipeline Conference. ; 2010

demonstration and trials. The project will provide a unique gas transmission test rig which, when coupled with the H21 distribution facility, will form the most comprehensive demonstration of hydrogen transmission, distribution and end use yet seen anywhere in the world.

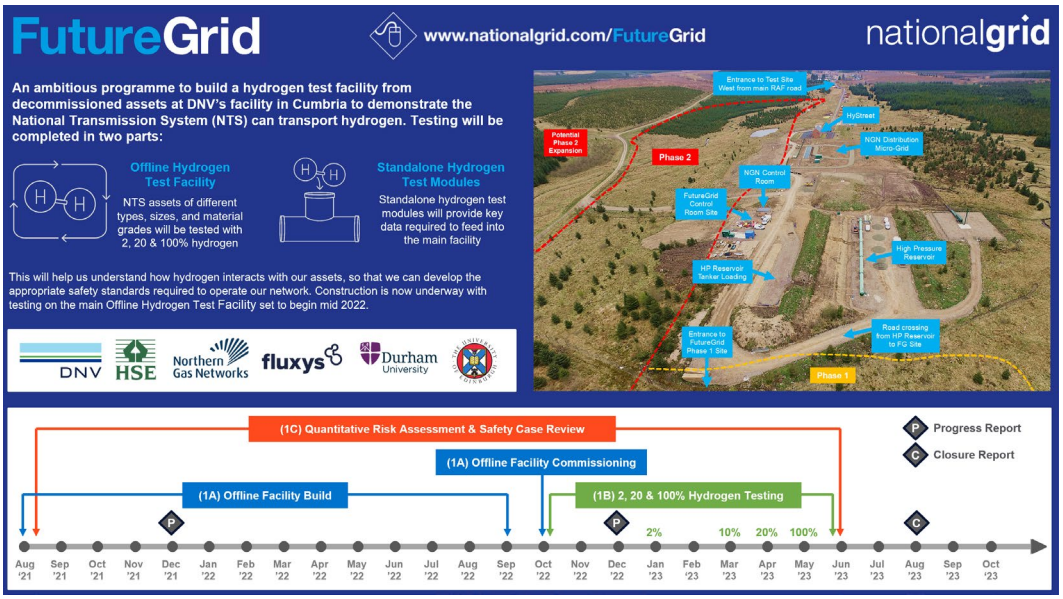


Figure 2 FutureGrid Project

2.3.8 NIA NGN Service Testing Project.

This project was delivered for Northern Gas Networks as part of a NIA project for hydrogen. A bespoke test rig was designed to allow for measurement of the pressure drop through various service pipework configurations as gas companies like NGN would lay them in current distribution networks. The rig allowed for the pressure drop over different lengths and diameter pipes to be tested with both hydrogen and methane A second configuration of the rig allowed for the same tests to be conducted through a service pipe, with top-tee and excess flow valves. Various fittings could be added to the pipework under test to determine what challenges lie ahead with transitioning from natural gas to hydrogen-fed homes.

2.3.9 DNV Hydrogen detection monitor project.

DNV has undertaken some self-funded research for hydrogen detectors. Domestic CO detectors typically make use of an electrochemical cell which generates a current when exposed to carbon monoxide. This cell is also sensitive to hydrogen meaning that a current is also produced under exposure to hydrogen. In both cases, the current is sufficient to trigger an audible alarm within the detectors. A short test programme was carried out to assess the sensitivity of these cells to hydrogen, and what conditions were required to trigger an alarm. Devices manufactured by various well-known brands were placed in a test enclosure and exposed to controlled hydrogen concentrations to determine the hydrogen concentration at which an alarm would sound, and the speed at which an audible alarm could be heard following exposure.

3 METHODOLOGY

This section of the proposal conveys the anticipated basis of safety which DNV proposal to use to deliver the experimental works described in the Lot responses to the ITT.

3.1 Basis of Safety

Spadeadam Research and Testing is in a remote region of Cumbria and has been in operation for over 40 years conducting major hazard experiments primarily for the Oil and Gas and Security industries. The site has extensive experience of the management of experimental programmes where there are significant safety hazards if the work is not appropriately managed. Procedures are enforced for the planning and conduct of experiments to ensure that the hazards are identified, evaluated and controlled to ensure all personnel are in inherently safe locations and that the risk of an unplanned realisation of a hazard, which may delay experimental progress, is minimised.

DNV operates all experimental programmes according to a set of site rules which require experimental procedures to be developed, fully peer reviewed and signed off by senior site personnel prior to commissioning test rigs. The procedures use engineering knowledge, experience and predictive tools to set exclusion zones around test areas for the safe conduct of any experiment. The exclusion zones are chosen to be conservative in size, an aspect that can be readily accommodated given the area available on the DNV site. The experienced team of test engineers on site are competent in hazard identification, risk assessment and elimination or mitigation of hazards.

Coordination of tests on site is through a single point, the central Site Control Room[4]. All tests that are potentially hazardous must obtain permission to proceed from Site Control. Site Control will liaise with other site users to ensure that there are no conflicting activities, will confirm that all physical barriers to prevent access are closed and scan the surrounding area with CCTV. Communication on site will generally be by two-way radios, though fixed line telephones are also available.

The DNV site is located within a secure military establishment (RAF Spadeadam). Where the effects of any test may extend offsite or potentially affect low flying aircraft (such as an explosion or large fire), Site Control will obtain permission to conduct the experiment from RAF Control. The larger remit of RAF Control allows exclusion zones extending beyond the DNV site boundary to be defined if required.

Figure 3 shows an aerial photograph of the general site layout with the location of the recently constructed research houses indicated. The DNV site is approximately 2.8km in length East to West and up to approximately 350m wide North to South.

[4] Procedure OP-OBG-5-SPA-083 Safety Control Room Operations

Figure 3: Spadeadam site location

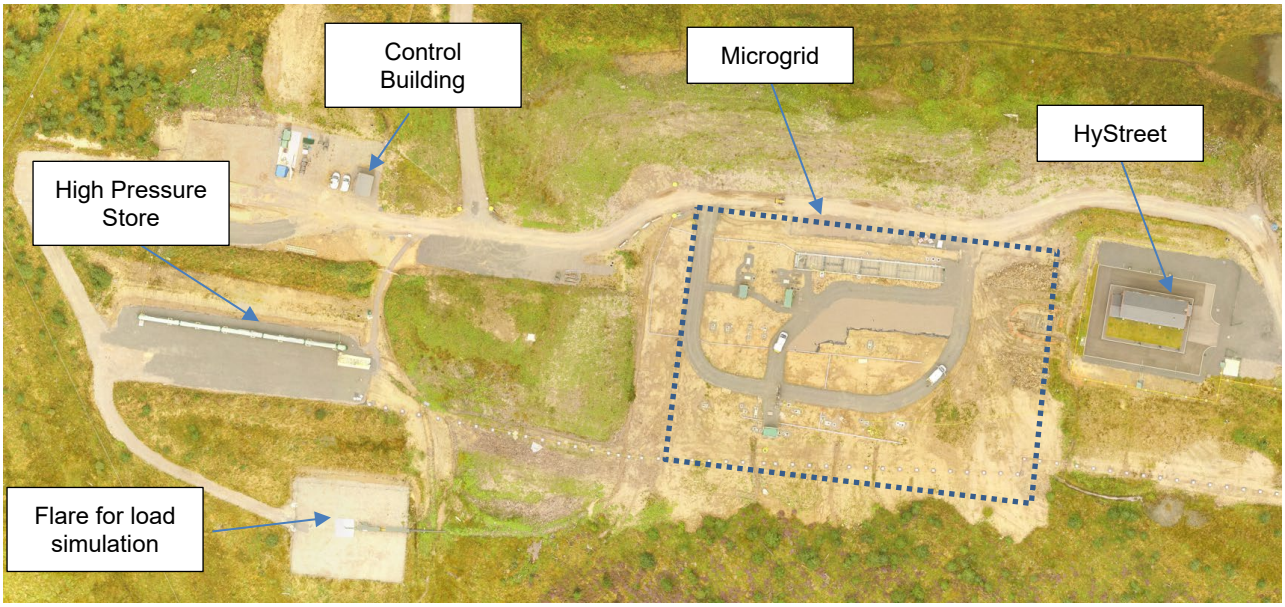


Figure 4: Microgrid and HyStreet Arrangement

4 QUALITY ASSURANCE

There are several elements to the approach DNV adopt in relation to Quality Assurance that depend on the issues being addressed. These elements are described in the following sections.

4.1.1 Planning

It is important to ensure at the planning stage that the experimental programme will achieve its objectives. The plan for each experimental programme will therefore be independently reviewed to ensure:

- The schedule of experiments meets the objectives set by, both strategically and in detail.
- To confirm that the measurements to be carried out are appropriate for each experiment, both in their nature and where relevant, their location.
- To confirm that the instrumentation to be used in the experiments is suitable for the task and that there is an adequate calibration plan.
- To ensure that the data acquisition and recording methodology is appropriate.

4.1.2 Testing

During the test programme, observations will be carried out for a sample of tests to ensure that the testing procedure is being followed and that instruments are appropriately calibrated.

The raw data captured will be sampled to confirm quality and whether it is self-consistent.

Recommendations for improvement will be provided to the Project Manager should any issues be identified.

4.1.3 Data Analysis and Reporting

During data analysis and reporting, quality assurance will be carried out to ensure:

- The processing of the raw data is appropriate and does not misrepresent any of the data gathered in the experiments.
- That the presentation of the data gives an appropriate and true picture of the findings from the experimental study.
- That the conclusions drawn from the analysis are appropriate and can be supported by the data.

4.2 Risk Management

4.2.1 Safety

A significant part of the risk management is encompassed by the development of a test procedure as this will ensure that:

- Personnel will be at an inherently safe location during any test.
- The conduct of the experiments is consistent with the well tested site safety procedures.

- The potential for an unplanned event that could delay or terminate the test programme is minimised.

The conduct of the tests will be coordinated by Site Control, ensuring that there are no conflicts on site.

4.2.2 Information Security

Almost all the data collected will be in digital form. Once an experiment has been completed, this data will be transferred to secure DNV servers. These servers have reliable back-up, ensuring that data will not be lost.

Data to be supplied to BEIS can be provided by an agreed secure means, either by encryption or a secure web-based site. This can be discussed at the initial project meeting.

Data will be provided in a format that can be interrogated by BEIS, though the file formats for data transfer will need to be discussed with the project. Some data translation is relatively simple and can be automated. This is within the current price, but no allowance has been made for an extensive data conversion process.

4.2.3 Achieving Acceptable Data Acquisition

DNV suggests an agreement with BEIS on what level of data constitutes an acceptable test. If any test does not achieve this agreed acceptability level, DNV commits to repeating the test at no cost to the BEIS project.

4.2.4 Schedule

Schedule risk will be managed through the planning and project monitoring process. Particular issues that need to be explicitly addressed in this process are the availability of personnel and equipment. It will be the responsibility of the Project Manager and Project Engineers to ensure this is carried out appropriately.

Where deviations from plan are identified, they will be communicated to the BEIS Project Manager, identifying the causes and the recovery plan, where possible and appropriate.

5 SCHEDULE

A nominal schedule for each lot is shown in each separate document.

A full schedule will be submitted with the project plan for agreement between BEIS and DNV.

6 DELIVERABLES

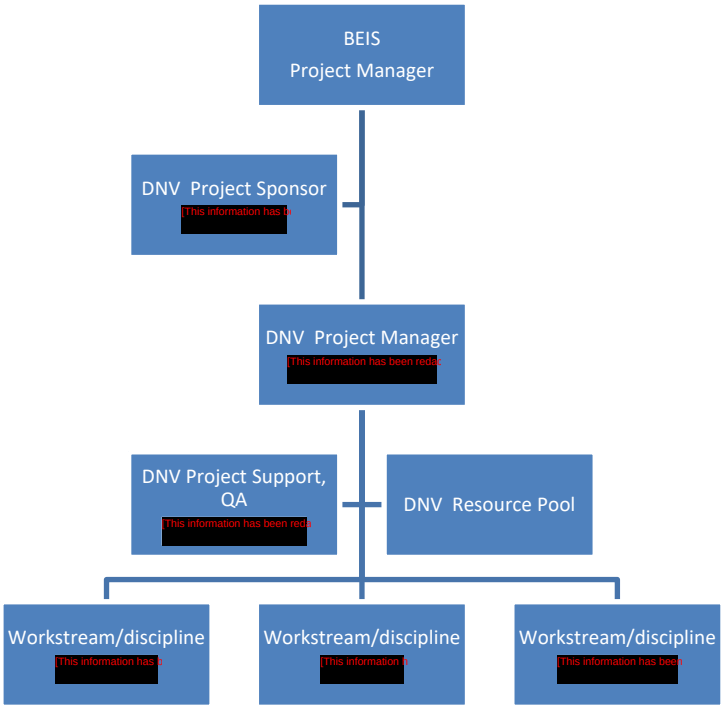
The deliverables listed in the ITT will be supplied at the appropriate points in the project for each Lot, these are:

1) Presentation at Project Inception Meeting
    a) Proposed Approach, testing plan and schedule
2) Final Project Plan
    a) After comment from BEIS
3) Progress Updates
    a) Minutes from regular update meetings between the DNV staff and BEIS Project Manager
4) Interim Meeting Presentation
    a) Experimental progress and findings from the first 50% completion of the project
    b) Delivered at BEIS team meeting in the UK (or online)
5) Interim Project Report
    a) Formal report detailing the progress, data and findings at the 50% completion stage.
6) Final Presentation
    a) Presentation of the draft findings at the completion of experiments and analysis
7) Written Report
    a) Report on Literature Survey
    b) Detailed written record of experiments detailing the experimental arrangement, methodology, results and any analysis / conclusions from the project.
8) Electronic Data Set
    a) All data recorded throughout the project. This will include the raw, quality checked data set as well as any processed data and details of the processing methods used.

7 PROJECT ORGANISATION

7.1 Organigram

The project will be managed by an experienced Project Manager and DNV is pleased to present a team of well qualified and experienced engineers for this project.



7.2 Key Personnel

This section gives a brief presentation of proposed project members. See DNV CV folder for CVs.

The proposed key personnel for the project are listed in the table below.

Table7-1 Key Personnel

Name	Project Role	Key Qualification and Experience
[This information has been redacted]	Project Sponsor	[This information has been redacted] is a Vice Presdient in DNV and is a Chartered Engineer with over 30 years' experience in the gas industry, working in both the natural gas and LPG market sectors. He has expertise in fire and explosion, gas storage, distribution, utilisation, emergency service provision and the investigation of incidents. [This information has been redacted] manages the DNV Spadeadam Research and Testing and has investigated over 100 fatal and non-fatal gas related incidents including fire, explosion, BLEVE and carbon monoxide poisoning. In this role, he has provided expert support in relation to several incidents in both criminal and civil litigation.
[This information has been redacted]	Project Manager	[This information has been redacted] is currently Principal Project Manager for Spadeadam Engineering & Development, responsible for overseeing the bids and delivery of large projects & programmes (Up to £10m), supporting the business commercially and overseeing the overall performance of the project portfolio.

The table below shows an overview of expert personnel and other resources that will be involved in the project on an as-needed basis.

Table7-2 Project Personnel

Name	Project Role	Key Qualification and Experience
[This information has been redacted]	Project Lead – Lot 1,5 & Testing	A Chartered Physicist with over 14 years experience delivering Major Hazards research at the Spadeadam Research and Testing. [This information has been redacted] is the Head of Section for Research and Innovation and works alongside the site's Project Delivery team to deliver complex research programmes ranging from small scale product development tests to large scale explosion experimental programmes for a range of international clients. Currently leading the experimental part of H21 Phase2a and 2b. [This information has been redacted] is also a PMP Certified Project Manager.
[This information has been redacted]	Project Team - QA	[This information has been redacted] has over 40 years' experience in safety, risk and reliability studies, originally joining British Gas Research & Development, now part of DNV. He is a Chartered Physicist and

		has led a number of major experimental projects associated with loss of containment events. He continues to provide technical support and QA on current experimental projects. He has investigated over 60 domestic gas explosion incidents.
[This information has been redacted]	Project Lead - Lot 2	[This information ha] has worked in energy utilisation and combustion for more than 30 years. During this time he has been involved in a range of projects focusing on the improved use of energy and minimisation of emissions. [This information ha] has been involved in technology development, validation and evaluation over a very wide range of scales from small domestic systems upto large burners for power generation. He has a wide knowledge of combustion modelling and engineering, and has led the development of gas/renewable energy hybrid systems. [This information ha] has led several projects looking at the impact of gas quality on emissions, hydrogen utilisation developments and equipment performance.
[This information has been re]	Project Lead - Lot 3	[This inform] has worked in industrial corrosion control for more than 32 years and is presently involved in consultancy for a wide range of oil and gas transport, processing and production activities. Consultancy roles performed include corrosion management planning, project management, corrosion engineering, production chemistry and flow assurance. A specific areas of technical expertise include is hydrogen compatibility and embrittlement of pipeline materials.
[This information has been redacted]	Project Lead - Lot 4	[This information has beer] is a Chartered Engineer and a Member of the Institution of Gas Engineers and Managers. He has 40 years of experience in the natural gas sector, primarily in gas transmission pipeline and distribution network planning, design and operation. [This information has beer] is Chair of an IGEM Panel updating the IGE/GL/1 Standard “Planning of gas distribution systems of MOP not exceeding 16 bar” and Member of IGEM Panel updating IGE/GL/2 Standard “Planning of transmission and storage systems operating at pressures exceeding 16bar”. [This information has beer] has experience in network planning, modelling and analysis

		both for infrastructure development and for System Operation and network management.
[This information has been redacted]	Project Team Resource	[This information has be] is an Incorporated Engineer and Member of the Institution of Gas Engineers and Managers, with over 40years of experience in the natural gas sector, primarily in the gas utilization, gas safety management, metering, distribution design, construction, operation and maintenance. [This information has be] is a Senior Principal Consultant within the Engineering, Research & Development department within DNV, responsible for project management and professional consultancy delivery. [This information has be] is also currently working on a number of projects including, hydrogen conversion planning, defence infrastructure organisation gas management planning and distribution network innovations,involved in all aspects of the project delivery from team management, stakeholder management, in-country delivery, due diligence, technical and financial workshops, viability studies.
[This information has been redacted]	Project Team Resource	Graduating in the summer of 2020 with a First Class (Hons) in MEng Chemical Engineering, [This information h] has worked on a variety of projects and DNV Spadeadam Research and Innovation Centre. He joined DNV as a graduate having extensively researched various electrocatalysts to produce hydrogen via anion exchange membrane water electrolysis. [This information h] has recently been involved with the H21 Northern Gas Networks project to process and present large data files for Phase 2A of H21, looking at the response of the gas transmission network to the introduction of hydrogen.
[This information has been redacted]	Project Team Resource	[This information h] has over 30 years extensive experience in gas network operations, construction, modelling, analysis and planning of gas infrastructure. He has lead and delivered significant research projects. [This information h] has specialised in the network analysis and planning of below 7bar networks, of the UK NTS (National Transmission System) and of transmission systems in general. [This information h] has provided consultancy services for gas

		distribution companies to review their network design and planning strategies and processes. He has been involved in the development of network analysis and planning policies and procedures for the effective management of networks and the support of R&D projects.
[redacted]	Project Team Resource	[redacted] is a computational mathematician working in a team which develops Network Analysis solutions. He is familiar with the principles of modelling flow within pipework and the flow equations used. He has been involved in adapting some of DNV's products to model hydrogen.
[redacted]	Project Team Resource	[redacted] is a process safety professional with 14 years'experience providing support to over 80 organisations in the oil & gas, chemicals, pharmaceuticals, manufacturing, and nuclear Major Hazard industries. His technical experience covers a wide range from management systems to quantified risk assessment, human factors and safety cases.
[redacted]	Advisor, Project Resource	[redacted] a world leading scientist of British Gas heritage and an expert in gas accumulation, dispersion and QRA. [redacted]s currently involved with the H21 project conducting model evaluations and updates feeding into a revamped QRA tool for the prediction of risk of a hydrogen network

The resources listed above are based on DNV's current availability schedule. Should project personnel availability change at the time of contract award or during the project execution, DNV will inform the customer of the changes of resources. DNV will aim at finding resources with the same level of competence as the resources listed.

7.2.1 Resource Pool

DNV would like to emphasize that we have a large pool of highly qualified engineers/consultants/inspectors available within numerous disciplines. If needed due to changes in the schedule or scope of work, or to resolve additional customer challenges, a significant number of very experienced resources can be mobilized for the project.

8 CONTRACTUAL

8.1 Contract basis - Terms and Conditions

We have reviewed the proposed terms and conditions and state the following qualifications and/or comments. DNV is assuming all the lots will be under one contract.

8.2 Assumptions, conditions, and limitations

DNV are in the process of getting Group Legal approval for this contract.

9 COMPENSATION

9.1 General

All rates and prices provided in this proposal are quoted in and exclusive of VAT or any other taxes.

9.2 Lump sums

The activities associated with each Lot include a lump sum table detailing costs. Please refer to each Lot document for details.

A summary of lump sum costs is detailed below:

Lot	Lump Sum Cost (GBP)
Lot 1	[This information has been redacted]
Lot 2	
Lot 3	
Lot 4	
Lot 5	
Total	

9.3 Rates and Expenses for Variations

Any additional works agreed with the BEIS team will be conducted on a fixed price variation built using the following rates:

Table 3: Day rates for variations

Person	Day Rate
P.Cons	[This information has been redact
Cons	
Snr Eng	
Eng	
Tech	
Materials and Expenses	

9.4 Invoicing and Payment

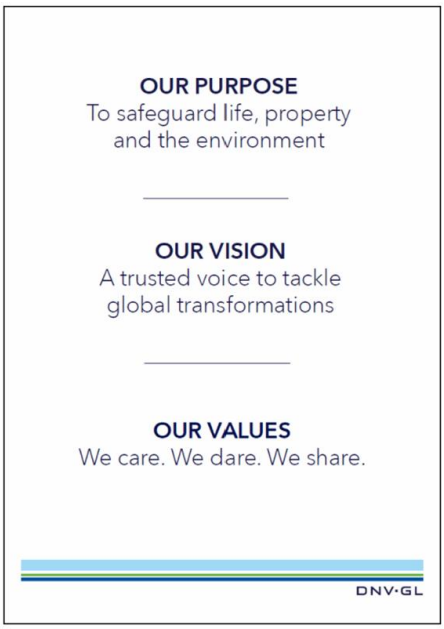
Invoicing throughout the project will be in accordance with the milestones detailed in the ITT.

10 DNV SOCIAL VALUES

Our Purpose is our reason for being. Our Vision expresses our ambition for the business and sets a direction in the long term. The new Vision will guide the development of the 2021-2025 strategy. The new Vision complements our Purpose, rather than repeating it.

"I believe that our new Vision perfectly expresses the way we should pursue our purpose in the next decade – in a world where life, property and the environment are a triangle of interdependence," says Group President and CEO Remi Eriksen.

Our Values are beliefs that shape our performance; these ideals are the behaviours expected of all of us and are important for achieving our Purpose and our Vision. The main objective of revisiting our Values was to modernize and simplify them. The new Values are the result of input from employees across the organization.



Our Purpose is our reason for being. Our Vision expresses our ambition for the business and sets a direction in the long term. The new Vision will guide the development of the 2021-2025 strategy. The new Vision complements our Purpose, rather than repeating it.

"I believe that our new Vision perfectly expresses the way we should pursue our purpose in the next decade – in a world where life, property and the environment are a triangle of interdependence," says Group President and CEO Remi Eriksen.

Our Values are beliefs that shape our performance; these ideals are the behaviours expected of all of us and are important for achieving our Purpose and our Vision. The

main objective of revisiting our Values was to modernize and simplify them. The new Values are the result of input from employees across the organization.

WE CARE for each other, our customers, our planet, and we take care of ourselves.

WE DARE to explore, to experiment, to be different, and to be courageous, curious and creative.

WE SHARE our experience and knowledge. We collaborate with each other and our customers, and we continue to grow and develop as a result.

10.1 DNV Energy Transition Outlook

This annual outlook, now in its fifth edition, presents the results from our independent model of the world's energy system.

This annual Outlook presents the results from our independent model of the world's energy system. It covers the period through to 2050 and forecasts the energy transition globally and in 10 world regions. Our forecast data may be accessed at eto.dnv.com/data. More details on our methodology and model can be found on page 34 of the document (via the link). The changes we forecast hold significant risks and opportunities across many industries.

Some of these are detailed in our supplements:

- Maritime forecast
- Financing the energy transition
- Technology progress report
- Pathway to net zero emissions (to be published in October 2021)

10.2 Contributing to the Governments Environmental Goals

DNV has a tender process and sustainability aspects are considered an important aspect of any decision in our supply chain. As part of our approach to sustainable procurement, all suppliers are required to adhere to our Supplier Code of Conduct and consider how they can support our sustainability goals in their own operations, including our environmental policies and standards. We also work with suppliers to establish & encourage them to have a progression plan towards a commitment to be carbon neutral. This includes initiatives such as a "clean van commitment" target and for energy usage to achieve carbon neutral targes by 2030.

Achieving the Governments clean air targets include:

- meeting legally binding targets to reduce emissions of five damaging air pollutants; this should halve the effects of air pollution on health by 2030
- ending the sale of new conventional petrol and diesel cars and vans by 2040
- maintaining the continuous improvement in industrial emissions by building on existing good practice and the successful regulatory framework
- Minimise waste by reusing materials as much as we can and manage materials at the end of their life to minimise the impact on the environment.

To contribute towards these targets, DNV senior leadership have been proactive in canvassing employee opinions on future working arrangements, and it is likely that substantial changes will be implemented in the longer-term. For example, office footprints will be reviewed as leases come up for renewal and it is expected that there will be a substantial reduction in office space over time, reducing greenhouse gas emissions through reduced commuting and building services.

For office leases signed in 2020, we have successfully reduced floor space per employee from an average of 25 m2 in 2017 to 17 m2 by the end of 2020. This contributes to a reduction in energy consumption and related CO2 emissions.

Green initiatives have been introduced including eliminating the use of plastic cups/utensils, minimising the amount of printing and recycling of waste paper all help to lower carbon emissions. In addition, we have learnt during the past year that most business communication can be effectively carried out virtually, and a significant permanent reduction in business travel and commuting into work is expected, again having a positive impact on climate change. It is anticipated that increased home working will be a permanent result of the changes made due to the pandemic, and this will have the added benefit that staff no longer need to be based locally to other members of their team. This opens up the possibilities of cross-team and international working, so drawing on a greater pool of expertise.

DNV conducts extensive research to understand the challenges facing our climate, oceans, energy systems, food, healthcare and transport systems. We use our technical expertise to accelerate the transformation in line with Sustainable Development Goals (SDG's) and the 1.5°C target to create a better future. DNV will ensure our worldwide operations are responsible and sustainable. By 2025 DNV will select energy suppliers so our offices and laboratories will be supplied with 100% renewable electricity and our operation will be climate net positive by a meaningful margin. Our Energy Transition Outlook shows that extraordinary measures are required to achieve the ambitions of the Paris Agreement. To fulfil our Purpose of safeguarding, life, property and the environment we work together with suppliers and customers to achieve decarbonisation in line with the Paris Agreement goals. How we do this will be embodied in the GHG compass which will give us a common understanding in suggested areas of improvement and structured way of working to accelerate the energy transition. The GHG compass is a tool which will reinforce a purpose-driven business and mindset around deep decarbonization, guide our strategic and business priorities, such as our investment and innovation priorities, identify which customers and suppliers to prioritize, identify what work to scale up, down or stop to increase our impact on accelerating the energy transition and measure and demonstrate a meaningful impact related to UN Sustainable Development Goal (SDG) #13 – Climate Action through our work with customers.

We calculate our GHG emissions in line with the GHG Protocol. We use the financial and operational control approach, with the operational control criteria defining the boundary for consolidating the greenhouse gas emissions. Location-based emissions are reported globally. We use Defra CO2 emission factors for calculating air travel, chemical consumption and fossil fuel use. We use SECR energy and carbon reporting scheme s to improve transparency and help reduce UK carbon emissions associated with business and industry. The results are shared on our intranet and also reported in DNV's Annual Report. We report in accordance with the Global Reporting Initiative Standards: Core option. We measure and monitor our key environmental aspects and any environmental incidents using Synergi Life software, which was developed in-house. We measure GHG emissions from air and rail travel with reporting tools from our travel agencies.

TABLE 14 | ENERGY CONSUMPTION (GWH)

	2020	2019	2018
Energy consumption	57.3	94.8	109

TABLE 15 | GREENHOUSE GAS EMISSIONS (THOUSAND tCO_2e)

	2020	2019	2018
Scope 1: Direct GHG emissions from operations	1.5	25.6	5.7
Scope 2: Indirect GHG emissions from purchased electricity and heat	8.9	13.9	17.2
Scope 3: Indirect GHG emissions from air, car and rail travel	12.9	38.4	41.9
Total GHG emissions	23.4	77.9	64.8

Scope 1, 2 and 3 GHG emissions per person from DNV operations were 2.02 tCO_2e per employee (2020: 6.6).

100% of our emissions in 2020 were offset through verified schemes.

23.4 thousand tonnes of CO_2e emitted from offices, lab operations, air and car travel.

-55% Reduced emissions in 2020, mainly as a result of the pandemic.

FIGURE 05 | GHG EMISSIONS (THOUSAND tCO_2e)

	2020	2019
Air travel	8.7 (37%)	33.8
Buildings	10.5 (45%)	17.0
Car travel	4.2 (18%)	4.6

Basis of reporting GHG emissions

Scope 1 and 2 emissions come from DNV burning of liquid fuel and gas within our offices and energy consumption.

We have included our scope 3 emissions that come from business air, rail and car travel.

We do not yet have other sources of scope 3 emission data from our vendors, contractors or supply chain.

38% of the electricity used at DNV in 2020 was from renewable energy sources.
Remote surveys in Maritime increased by 33% last year.
DNV Energy conducted more than twenty remote inspections on wind farm projects with a cumulative capacity of over 500 MW in the US, Poland, China, Sweden and the UK.
Business Assurance were able to conduct 40% of all customer audits remotely.

In addition to DNV's commitment to reduce its carbon footprint through its own personnel and working practices, its influence on climate change is broader due to its role as a leading advisor to the UK energy industry. The company is at the forefront of research into the transition to hydrogen, providing research and testing at its Spadeadam facility in Cumbria (as part of the H21 project), as well as statistical and engineering support to other projects (H100, HyNTS). DNV also works in the areas of renewables and developing robust future power systems, to support the transition to a cleaner energy future. We have provided the Cycle to Work Scheme for many years under a Salary Sacrifice Scheme and in May 2021, DNV introduced a Salary Sacrifice Scheme for all employees to encourage the uptake of driving electric cars.

On a global level, DNV has a number of partnerships for sustainable development. We collaborate with several organisations, contributing our expertise in technology and sustainability as well as providing funding to reach shared goals.

11 DNV MANAGEMENT SYSTEM

The DNV Management System is an integrated quality, HSE (health, safety and environment) and business administration management system.

DNV's Management System is certified to ISO 9001, ISO 14001 and ISO 45001. There is one ISO 9001 certificate for each of DNV's business areas, while Group wide certificates apply for the ISO 14001 and ISO 45001 certification.

All certificates are issued by the Dutch accredited certification body DEKRA Certification B.V.

A description of DNV's quality and HSE policy and Management System is provided in Appendix A.

APPENDIX A
DNV Management System

General

The DNV Management System (DMS) documents are sorted under 17 strategic areas as an index for the management system. The DMS seeks to be independent of the organisational structure, and able to show the main processes of the company.

The management system documentation consists of:

- The DMS – DNV's Management System documentation. This is a 2-tier system. The top tier is owned, issued and maintained at DNV Group level and is valid for all in DNV. The ownership of the various groups of strategic areas has been assigned to DNV Group directors, to ensure anchoring with top management, focus and development.
- The second tier is owned, issued and maintained at DNV Business Area level and is valid for all in the respective DNV Business Area.
- Local Operating Procedures (OPs) which are specific for an operating unit, or part of the line organisation, i.e. Regional OPs.
- Country specific OPs which are valid for a country, typically covering employment items and general compliance with national legislation.

All management system documentation is available to all employees on the DNV Intranet.

DNV monitors, measures and improves the effectiveness of its management system on a continuous basis where opportunities for improvement are identified through internal and external audits, experience feedback, after-action reviews and, most importantly, through dialogue with and feedback received from our customers. The annual Management System Review is an important instrument in this regard.

DNV has a common tool for follow-up of all events such as audits, non-conformities, complaints and potential quality issues called Quality Event Tracker - QET. All quality events shall be registered in QET. QET facilitates the use of root cause analysis and ensures that events are handled and closed after proper actions have been taken.

Quality

DMSG-12-0 Quality Policy

DNV's ambition is to have a leading position in all industries where we operate whilst never compromising on integrity and quality.

We commit ourselves to:

- Deliver in accordance with stakeholders' expectations
- Continually improve our performance

This is achieved through:

- Serving our customers with a high degree of pro-activeness and responsiveness

- Complying with applicable standards and regulations
- Continually improving our services
- Continually improving our management system
- Continually investing in research and innovation
- Striving to be at the forefront of technology
- Striving to attract, develop and retain leading competence

Quality Management System

The strategic areas most important in relation to quality of customer-facing activities and project deliverables are:

- Customer management
- Service lines
- Production
- Innovation, research and development
- IT and information management
- Quality and management system

Under the strategic area Production there are governing documents addressing:

- Project management
- Internal verification of project work and approval of deliverables
- Performance of various categories of services
- Requirements to certain types of deliverable documents
- Competence management and requirements

Further document types are:

- DNV Service Specifications
- Internal Service Instructions
- Internal Service Guidelines

Health, Safety and Environment (HSE)

HSE Policy

- We know that our work is never so urgent or important that we cannot take time to do it safely. We feel confident and empowered to stop work and to intervene where inappropriate behaviour or unacceptable conditions are encountered.
- We identify and assess risks to the health and safety of people, property or the environment in our work. We ensure they are effectively managed and that areas for improvement are prioritised.

- We foster a culture where everyone is actively involved in setting a good example and pursuing, adopting and sharing good HSE practice.
- We develop, resource and implement HSE plans to deliver continual improvement in HSE performance. We openly report and appraise our HSE performance and measure our achievements against our plans and goals and take action to address shortcomings.
- We treat incidents including near misses and hazards and feedback from employees and customers as an important learning opportunity.
- We select our sub-contractors and suppliers based on their ability to provide services which meet our safety, health and environmental requirements.
- We work to the principles of the UN's Global Compact and participate in the World Business Council for Sustainable Development.
- We will visibly demonstrate leadership and commitment to high standards of health, safety and environmental performance.

HSE Management System

HSE is a separate strategic area, under which there are governing documents addressing:

- Environment aspects identification and management
- Emergency preparedness
- Implementation support and control processes, e.g. HSE risk assessment, HSE audits, incident reporting and investigation
- Health and Safety e.g. occupational health, substance abuse, field work, laboratory and test site, travelling and driving
- HSE Performance reporting and Management System Review