HyDeploy

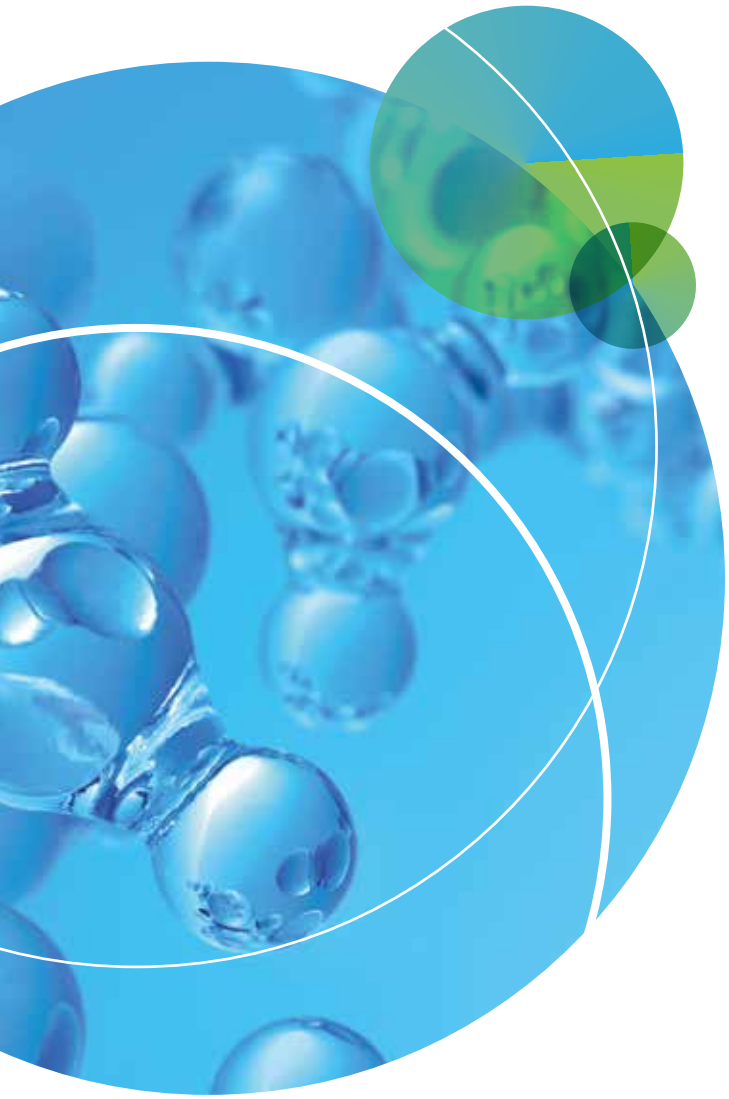
HyDeploy Project

Gas Network Innovation Competition // Cadent

Second Project Progress Report (PPR) // December 2018

HyDeploy

The HyDeploy project seeks to address a key issue for UK customers: how to reduce the carbon they emit in heating their homes. The UK has a world class gas grid delivering heat conveniently and safely to over 83% of homes. Emissions can be reduced by lowering the carbon content of gas through blending with hydrogen. This delivers carbon savings, without customers requiring disruptive and expensive changes in their homes. It also provides the platform for deeper carbon savings by enabling wider adoption of hydrogen across the energy system.



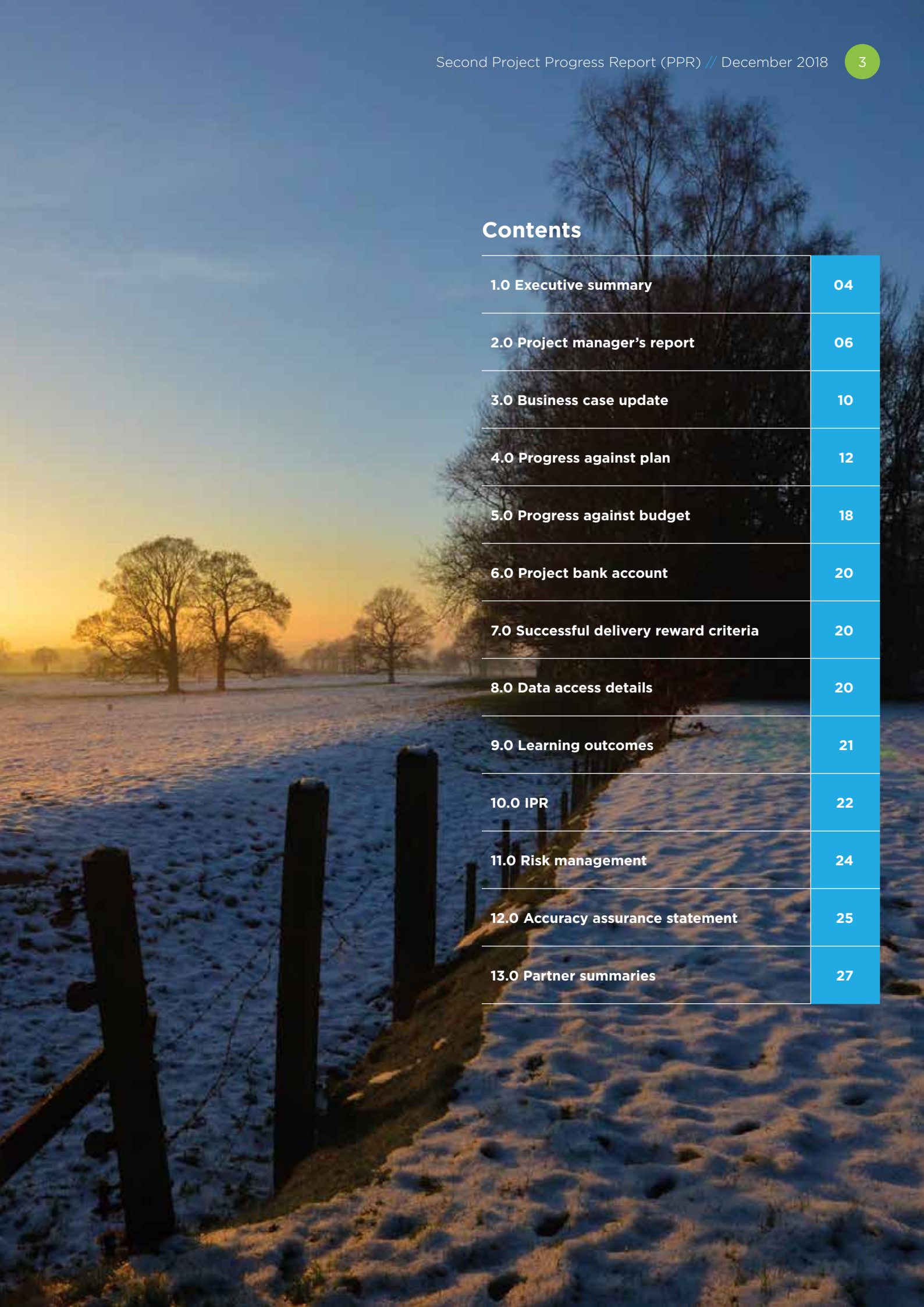
This Network Innovation Competition (NIC) funded project seeks to establish the level of hydrogen that can be safely blended with natural gas for transport and use in a UK network.

Under its smart energy network innovation demonstration programme, Keele University is establishing its electricity and gas networks as facilities to drive forward innovation in the energy sector. The objective of HyDeploy is to trial natural gas blended with 20%$_{mol}$ of hydrogen in a part of the Keele gas network.

Before any hydrogen can be blended with natural gas in the network, the percentage of hydrogen to be delivered must be approved by the Health and Safety Executive (HSE). It must be satisfied that the approved blended gas will be as safe to use as normal gas. Such approval is provided as an Exemption to the Gas Safety (Management) Regulations. These regulations ensure the safe use and management of gas through the gas network in the UK. Following such approval, hydrogen production and grid injection units are to be installed, and an extensive trial programme undertaken.

Blending hydrogen at 20%$_{mol}$ with natural gas across the UK, would save around 6 million tonnes of carbon dioxide emissions every year, the equivalent of removing 2.5 million cars from the road.

HyDeploy delivers carbon savings, without customers requiring disruptive and expensive changes in their homes.



Contents

1.0 Executive summary	04
2.0 Project manager's report	06
3.0 Business case update	10
4.0 Progress against plan	12
5.0 Progress against budget	18
6.0 Project bank account	20
7.0 Successful delivery reward criteria	20
8.0 Data access details	20
9.0 Learning outcomes	21
10.0 IPR	22
11.0 Risk management	24
12.0 Accuracy assurance statement	25
13.0 Partner summaries	27

1.0 Executive summary

The HyDeploy project has had a very successful year. The landmark achievement has been securing the Exemption to the hydrogen requirements of the Gas Safety (Management) Regulations. This has required development of an extensive evidence base drawing on scientific literature, specifically commissioned experimental work, and field testing.

Overall this has been a successful and productive year, making truly ground breaking progress.

Customers are at the heart of this project and through a well-developed engagement programme we have had their support, enabling us to deliver the project. Extensive laboratory work was undertaken to understand the implications for appliance operation of a 20%$_{mol}$ hydrogen blend relative to natural gas. This demonstrated that the appliances all operated safely on the blend. Based on these results, field testing was undertaken to ensure that the installations were all fundamentally safe on natural gas, and to confirm the findings from the laboratory, performing just as safely on the blend.

The scientific programme established the gas characteristics of a hydrogen blend relative to natural gas, underpinning recommendations relating to operational procedures on the network, the majority of which require no change. All relevant gas detectors underwent a rigorous testing regime and appropriate detectors selected for use during the trial. Ensuring that the hydrogen is properly and safely blended in the Grid Injection Unit is critically important. Following an extensive tender process, a manufacturer was selected and the design work undertaken to support the Exemption application, both in terms of process performance and integrity. Similar information was required in terms of the Electrolyser and balance of plant. The trial itself offers the opportunity to gather important data on network and appliance operation. The means by which this will be delivered has been defined, with excellent support from appliance and equipment manufacturers. The project team has continued to engage extensively with other European hydrogen blending programmes. There has been valuable collaborative sharing of data between these complementary programmes, which has supported the evidence base.

Together this body of evidence was used to develop a detailed Quantitative Risk Assessment of blending. The UK grid was modelled using the QRA and validated against historic data, and used to model the Keele network as found, and on blended hydrogen. This demonstrated that blending at 20%$_{mol}$ does not prejudice the safety of those affected by the trial. The Exemption application was submitted in June and was followed by a process of detailed challenge and review. Following the final determination on 1st November 2018, the project Steering committee sanctioned progression to the project construction phase.

In order to deliver widespread deployment of blending, there is a need to translate the work at Keele onto the wider public network. The plans have been developed to undertake follow on public trials. This will form part of a separate project, HyDeploy2 which has been awarded funding under the Network Innovation Competition 2018 and will commence in next year.

Throughout this year, the project team has engaged with wider stakeholders, particularly in regard to emerging government policy on low carbon heat, as well as presenting at a variety of conferences. The project is being carefully managed to deliver within budget. There have been some increases in costs due to the extent of the scientific programme required ahead of Exemption, as well as complexity of the grid injection unit, as previously identified. This has been mitigated through careful management activities to deliver the project within budget, but as with any project, this remains a risk through until it is complete. Similarly, there have been some delays in schedule, which is being managed through a tightly developed execution plan that has been developed for the next phase.

Overall this has been a successful and productive year, making truly ground-breaking progress. This is not only relevant to blending of hydrogen, but to the wider role of hydrogen in our energy system. This has been achieved through a competent, dedicated and engaged project team working collaboratively.

2.0 Project Manager's report

The HyDeploy project has had a very successful year, building on the early progress at the start of the project.

Key achievements

Undoubtedly the landmark achievement of the year has been securing the Exemption to the hydrogen requirements of the Gas Safety (Management) Regulations. The evidence base developed to deliver this is summarised below, along with other highlights of the year. The project team has also secured funding from the Network Innovation Competition to deliver the follow-on public trials, which are vital to enabling roll out, and which will follow on seamlessly from the trial at Keele University (Keele).

Customers are at the heart of this project. The rationale for the project is to enable consumers reduce the carbon impact of their heating without disruptive change. To deliver that in the context of the trial at Keele we needed to engage with the customers on the network to help them understand the purpose of the project and to arrange the necessary testing in their properties. This was very successful, building on the well-developed customer engagement plan. We had a dedicated customer liaison officer who became well known on site, explaining the project, facilitating bookings and putting the needs of the customers first.

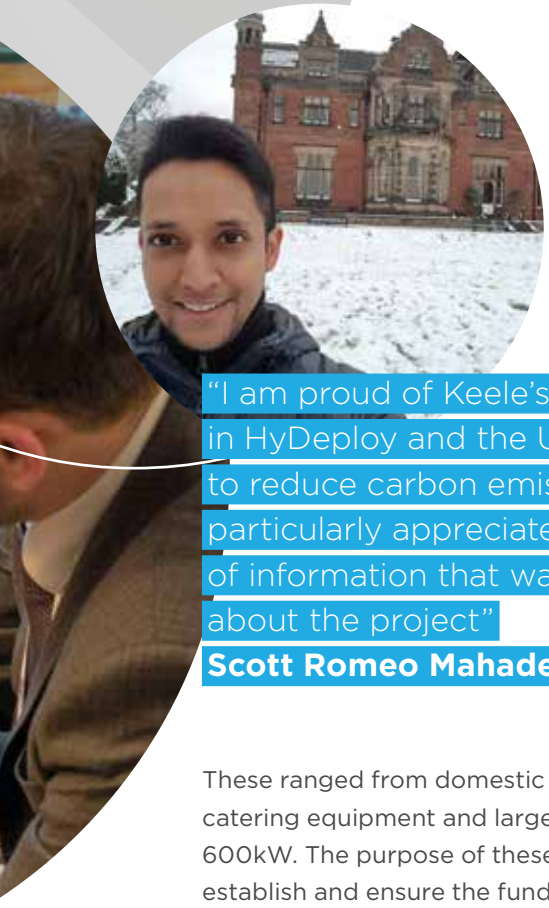
This field testing was part of the wider scientific programme to develop the evidence to support the Exemption. The HSE would only grant an Exemption if the project could demonstrate that the use of a hydrogen blend for the period of the trial at Keele would not prejudice the safety of those affected by the trial.

The Health and Safety Laboratory have managed the scientific programme for the project.

Customers are at the heart of this project. The rationale for the project is to enable consumers reduce the carbon impact of their heating without disruptive change.

Extensive laboratory work was undertaken to understanding the implications on appliance operation of a 20% hydrogen blend relative to natural gas. Detailed testing in the laboratory was undertaken by Kiwa on a range of carefully instrumented gas appliances, including boilers, cookers and fires. A carefully selected range of gas compositions was used to envelope fully that which could be experienced at Keele during the trial. This demonstrated that the appliances all operated safely on the blend and that the components continued to operate within their design specifications. In addition, limit testing was undertaken to confirm that there were no significant non-linearities in safety behaviour well beyond the operational blend conditions.

Based on this laboratory work Kiwa, supported by a team of local gas fitters undertook field testing of installations and appliances across the network enabled by the communications programme. Over 130 properties and buildings were tested, including more than 230 individual appliances.



"I am proud of Keele's involvement in HyDeploy and the UK's initiative to reduce carbon emissions. I particularly appreciated the wealth of information that was provided about the project"
Scott Romeo Mahadeo

These ranged from domestic units to commercial catering equipment and large boilers up to 600kW. The purpose of these tests was (a) to establish and ensure the fundamental integrity of the appliances and installations on natural gas, and (b) to evaluate whether the findings in the laboratory were replicated in the field using bottled gas blends connected at the gas meter. In general, the installations and equipment on the Keele site were found to be well maintained, although some of the private properties required remedial work or replacement to bring them up to standard on natural gas. Performance in the field on blends fully replicated the findings in the laboratory, in all cases performing just as safely on the blend as on natural gas.

Alongside appliance testing a thorough network asset survey was undertaken to provide a baseline and identify equipment and materials that would come into contact with the hydrogen blend. This informed an extensive materials programme, comprising literature review and practical experimental work to understand the impact of the blend on material properties under the network conditions. Whilst hydrogen is known to have possible impacts on materials, particularly on metallic components, much of the literature on these effects was found to be focused on 100% hydrogen and operation at high pressures.

As such an experimental programme was developed to understand the likely effects on materials on relatively benign operating conditions during the year-long trial. This provided the necessary confidence that the network and components, such as control valves, would maintain operational integrity throughout the trial.

The scientific programme established the fundamental gas characteristics of a hydrogen blend relative to natural gas. This provided underlying data on expected changes, and underpinned recommendations relating to operational procedures on the network. The majority of the procedures required no change, but the evidence required to establish this position shouldn't be underestimated. This work included an important experimental workstream related to gas detection. Accurately detecting gas concentrations underlies safe operation of a network. All relevant detectors underwent a rigorous testing regime and recommendations were developed to enable safe management during the trial, as well as inform potential developments in equipment for the future.

The hydrogen must be properly and safely blended. Gas demand on a network is highly variable, and the grid entry unit must be able to meet the permitted blend level reliably. Following an extensive tender process, a manufacturer was selected and the design work undertaken to support the Exemption application, both in terms of process performance and integrity. Similar information was required in terms of the electrolyser and balance of plant. The operational transition from normal gas to the blend has been carefully assessed, and the process by which this is governed has been developed.

The trial itself offers opportunity to gather important data on network and appliance operation. Gas composition will be measured across the network to confirm it matches the modelled flows. The project has also had excellent support from the appliance manufacturers.

A test facility will be set up in one of the university boiler houses to allow accelerated testing of boilers supplied and instrumented by four key manufacturers. Similar support has been provided by analytical equipment suppliers.

The project team has engaged extensively with other European hydrogen blending programmes, in Holland, Germany and France. Engie commenced hydrogen injection in June 2018 at their project in Dunkirk, and have been particularly supportive of the HyDeploy programme. There has been valuable collaborative sharing of data between these two complementary programmes, which has supported the evidence base.

Together this body of evidence was used to develop a detailed Quantitative Risk Assessment (QRA). A comprehensive Fault Tree was developed which mapped the cause and effect of individual events across the gas system, including people factors. This comprised over 200 individual gates and events. Underlying data was collected regarding the wider gas network and the UK grid was modelled using the QRA and validated against outturn risk profile experienced historically. A good correlation was achieved with the model.

The QRA was then used to model the Keele network as found, demonstrating that it is a particularly safe network. This is unsurprising given it can be closely managed given its size, and the ability of the University as site owner to mitigate key business as usual risks. Operation of the network on blended hydrogen was modelled using the QRA. This demonstrated that, with the processes developed for Keele, blending at $20\%_{mol}$ does not prejudice the safety of those affected by the trial.

Throughout the development of the evidence base, the project team engaged closely with the HSE Officers responsible for this programme. The Exemption application was submitted on 25th June. This was followed by a process of detailed challenge and review with over 140 clarification questions which were addressed by the project team. A final determination was made on 1st November 2018, granting an Exemption to operate the trial at $20\%_{mol}$ blend on the Keele network. This was an extremely constructive process, with the regulator making a determination on a complex application in around four months.

In order to deliver widespread deployment of blending, there is a need to translate the work at Keele onto the wider public network.

On the basis of the Exemption the project Steering committee sanctioned progression to the next project stage on 1st November 2018.

In order to deliver widespread deployment of blending, there is a need to translate the work at Keele onto the wider public network. The plans have been developed to undertake follow on public trials. This will form part of a separate project, HyDeploy2 which has been successfully awarded funding under the Network Innovation Competition 2018 and will commence in 2019.

Whilst this year has been focused on the Exemption, the project team have been engaged with wider stakeholders, particularly in regard to emerging government policy on low carbon heat, as well as presenting at a variety of conferences. This included the formal launch of the project in London in February at the Institute of Civil Engineers.

The project has been presented at a range of events including those organised by the HSE, the Knowledge Transfer Network, IGEM and others. At the request of BEIS, the project was presented at COP24, the UN Climate Change Conference in November, as an example of UK projects showing leadership in delivering practical carbon savings. The Advisory Board has now convened three times, facilitating direct engagement with both national and international stakeholders. The frequency has increased at the request of the Board given UK policy makers focus on heat solutions. Public press statements were released on the granting of the Exemption.

Outlook for next period

The dominant activity is the construction of the equipment onsite to produce, blend and monitor the hydrogen blend in the network. In parallel, the necessary training will be developed and delivered for the operatives, gas fitters and others involved in managing the network and undertaking the trials. The development of the experimental programme is underway and will be fully implemented, including the necessary installation work. During this period, annual gas safe checks will again be offered to all customers on the network, and we will be developing the approach to gaining feedback from customers during the operational phase. First injection is scheduled for the third quarter of 2019, and a careful process has been developed to manage increasing the blend to the full rate, with a full programme of monitoring in place.

Key Challenges

As we enter the construction phase of the project, key challenges will revolve around managing programme budget and schedule. As previously flagged, both the installation costs as well as aspects of the scientific evidence programme have been subject to some increases. This has been mitigated through careful management activities to deliver the project within budget, but as with any project, this remains a risk through until it is complete. In terms of managing schedule risk, a tightly developed execution plan has been developed for this phase.

During this phase we will be continuing to engage with customers. This will be enabled by the relationships that have been built to date in the project. However, we are conscious that people lead busy lives, and so it may be a challenge to encourage them to make the time to provide us with the feedback we seek.

Overall this has been a successful and productive year of delivery, making truly ground-breaking progress relevant not only to blending of hydrogen, but to the wider role of hydrogen in our energy system. This has been achieved through a competent, dedicated and engaged project team working collaboratively.

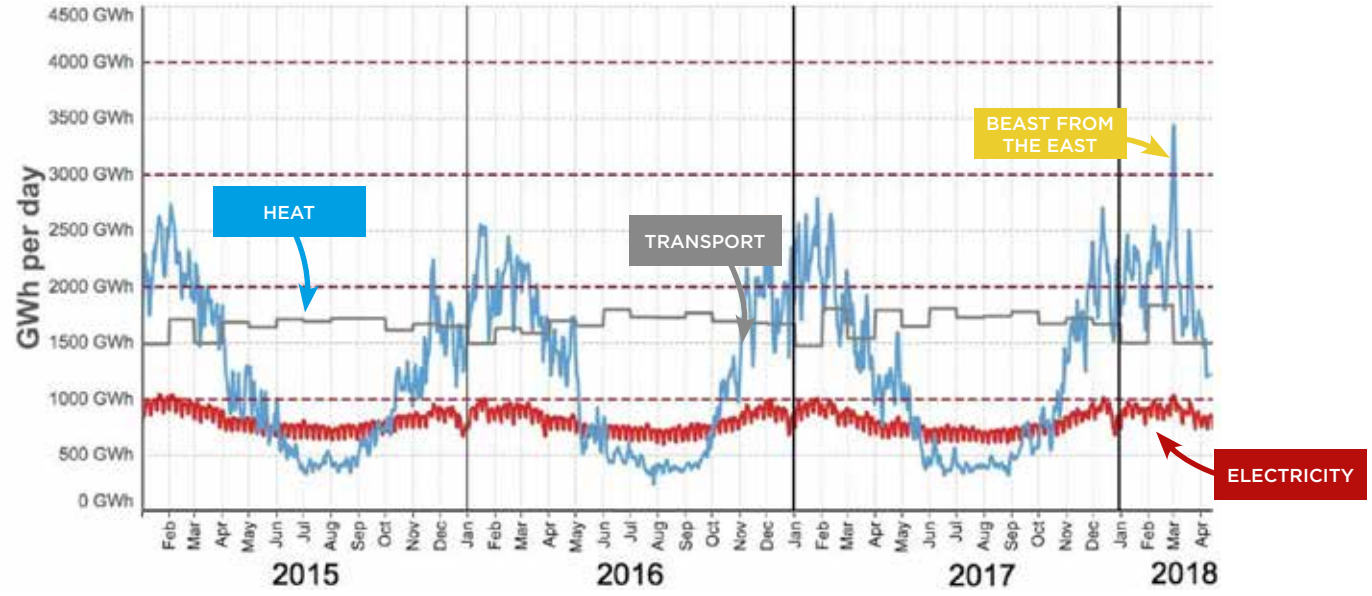
During this phase we will be continuing to engage with customers. This will be enabled by the relationships that have been built to date in the project.

3.0 Business case update

The UK is committed to a pathway to carbon reductions through the Climate Change Act. In 2016 it adopted its ambitious and legally binding fifth carbon budget for the period 2027-2032 as part of this trajectory. Heat contributes a third of the UK's carbon emissions. The updated Carbon Plan[1] and more recently the Clean Growth Strategy[2] specifically identifies the need for low carbon heat in order to meet these targets. As recently as June 2018, the Committee on Climate Change in its Progress Report to Parliament[3] highlighted that contrary to the vital need for reduction in emissions in this sector, ***'this year, emissions in the industry, buildings and waste sectors have increased',*** **and issued a call to action;** ***'Act now, climate change will not pause while we consider our options. And act in the consumer interest: pursue the low-cost, low-risk options'.***

The Carbon Plan identifies that by 2030 there is a requirement for between 83-165TWh of low carbon heat per annum. In 2017[4] the RHI delivered around 8.5TWh of renewable heat. In its 2018 RHI impact assessment[5], BEIS revised *down* its projections indicating '*that by 2020/21, the RHI could deliver 21.4TWh of renewable heat'*. Therefore, a step change in low carbon heat is required.

Great Britain has a world class gas grid and gas dominates its heat supply curve, heating 83% of its buildings and providing most of its industrial heat. Delivering low carbon heat via gas capitalises on existing network assets cost effectively and means that customers do not require disruptive and expensive changes in their homes. The importance and reliance of the UK on the gas network was exemplified during recent adverse weather conditions experienced during the 'beast from the east'.



UK Energy Demands[6]

[1] The Carbon Plan: Delivering Our Low Carbon Future December 2011, updated 2013.

[2] The Clean Growth Strategy Leading the way to a low carbon future, BEIS October 2017.

[3] Reducing UK emissions, 2018 Progress Report to Parliament, Committee on Climate Change, June 2018.

[4] RHI_monthly_official_statistics_tables_31_December_2017_final.

[5] https://www.legislation.gov.uk/ukia/2018/84/pdfs/ukia_20180084_en.pdf.

[6] Wilson G, Sheffield University. Source Date: National Grid, Elexon and BEIS.

Alternatives such as electrification using heat pumps will make a contribution. However, as recognised in BEIS Heat Strategy[7], in its RHI consultation, and in a 2018 report for the National Infrastructure Commission[8], this approach requires substantial consumer capital outlay and disruption, as well as substantial reinforcement of the electricity grid. This requires substantial additional generation, with recent work for the Committee on Climate Change[9] indicating that electrification of heat would require between 385 and 460GWe of installed capacity compared with around 100GWe today (and scenarios with reduced nuclear construction requiring even further renewable capacity).

The approach of this solution is to exploit this existing network by reducing the carbon intensity of heat delivered through blending of hydrogen delivering up to 29TWh per annum of low carbon heat. This approach requires no changes to appliances and network providing a non-disruptive to customers. It can operate seamlessly with a range of future heat scenarios, and provides a deliverable pathway. Cadent's HyNet NW project[10] demonstrates how blending into the local distribution zone to decarbonise domestic heat can work in combination with higher blends and full hydrogen in industry to deliver deeper decarbonisation. It also provides a platform for flexible hydrogen fuelled power generation to balance intermittent renewables, as well as facilitating complementary zero carbon solutions for transport. Critically blending enables customers to understand and become accustomed to hydrogen as fuel, develops large scale hydrogen production (including CCS), as well the supply chain and skills base.

This could therefore provide a pathway to conversion of elements of the gas network to full hydrogen as exemplified by the H21 project. However, that approach is focused on large conurbations, and so anticipates that there will remain a considerable element of the network still operating on conventional gas. Therefore, a natural gas-hydrogen blend will also have an enduring role.

[7] The Future of Heating, DECC 2016.

[8] Cost analysis of future heat infrastructure options, Report for, National Infrastructure Commission, Element Energy Limited, E4Tech, March 2018.

[9] 'Analysis of Alternative UK Heat Decarbonisation Pathways' Goran et al, June 2018.

[10] www.hynet.co.uk.

4.0 Progress against plan

The project is proceeding well against plan, with progress against each programme elements summarised below.

The application to the HSE for an Exemption was made in Quarter 2 of 2018. Some delays arising from governance processes onsite, as well as more extensive scientific assessment than originally anticipated meant that this was slightly delayed compared with the original schedule, as anticipated in the previous Project Progress Report.

The determination period also took slightly longer than planned, although given the significance of the Exemption and the magnitude of the evidence base, the HSE inspection team did a highly commendable job in determining it as expediently as they did. The formal move to the second phase took place at the start of November with fabrication and onsite works expedited. Some delays will flow through to commencement of the trial phase, but against the revised plan, the trial continues to encompass both summer low and winter peak

Programme element	Progress
1. Site communications and stakeholder engagement	An extensive communications and engagement plan was developed, submitted to Ofgem (first SDRC) and was approved under the relevant University governance process. Communications material was produced, including the project website with necessary booking processes and systems. A dedicated customer liaison officer facilitated a successful programme. Excellent customer participation was secured during the house to house testing phase, with positive feedback. This remains an important activity through the second and third phases of the programme, although the impact on customers is much less significant..
2. Pre-Exemption activities to develop the Exemption / safety case	This was the most extensive element of the programme during the first phase of the project, as it provided the detailed evidence base for the Exemption. This work drew on the national and international evidence base available, as well as detailed experimental and test work undertaken as part of the project. Work streams undertaken in this area included:
	(i) The effect of blended gas on appliances operation. An extensive laboratory testing programme of appliances was undertaken which provided important data as well as underpinning the design of the site appliance and installation testing. Over 230 appliances were tested onsite, each on natural gas and two hydrogen blends. During the onsite installation safety checks, all the pipework in the buildings will be leak tested.

Programme element	Progress
	(ii) The interaction of blended gas on materials. This work was based on an extensive literature review, combined with an asset assessment at Keele. In the laboratory, materials were exposed to a representative hydrogen environment and subsequently tested.
	(iii) Characteristics of hydrogen blended gas. To underpin the risk assessment and provide the basis for the evaluation of operational procedures, the underlying characteristics of the gas were assessed in terms of leakage, flammability, combustion and mixing behaviour. This also included assessment of the efficacy of gas detection equipment.
	(iv) Procedural assessment and development. The effect of hydrogen blended gas on existing gas management processes was assessed to ensure that risks are as effectively managed as they are today with just natural gas. It was demonstrated no changes were required in the majority of cases. Where adjustments were required, documentation was developed for implementation.
	(v) Safe and reliable blending of the hydrogen and natural gas. An integral part of the Exemption submission was the evidence that the hydrogen could be effectively blended and that the process equipment was safe.
	(vi) Trial management. This laid out how the trial will be managed and the associated governance procedures.
	(vii) Quantitative Risk Assessment (QRA). A detailed Fault Tree and QRA was developed with over 200 gates and basic events. This was benchmarked against UK data, and used to assess the Keele Network which demonstrated it to be a particularly safe site. Based on the scientific, operational and equipment assessments, blended operation was assessed, to provide the evidence that the use of blended gas on the Keele network, over the length of the trial does not prejudice the safety of those affected.

Programme element	Progress
3. Specification and design of hydrogen production and mixing units	During the first phase of the project a detailed functional specification was developed for both units. An extensive tender process was undertaken to identify and select a supplier for the grid entry and detailed design work undertaken. In parallel a basis of design and FEED was undertaken for the electrolyser, followed by detailed design. This information formed an integral part of the Exemption submission.
4. Write safety case and apply for GS(M)R Exemption	The structure and approach for the Exemption was developed early in the project to ensure that the evidence base being developed was properly focused. Throughout this phase, close engagement was maintained with the HSE inspectors to ensure that they were fully aware of the emerging evidence base. The full Exemption was submitted on 25th June 2018. This was followed by a period of robust interrogation including over 140 clarification questions, to ensure that the evidence was fully understood. An Exemption to blend at 20%$_{mol}$ for the trial on Keele's network was granted on 1st November.
5. Regulatory and billing arrangements	Billing. A billing regime for the trial phase has been agreed in principle with Ofgem. Based on the management system used by the University, the practical details have been developed to implement the approach. Electrolyser ownership. This has proven to be a greater regulatory challenge than had been originally anticipated. Given the small scale of the operation there had been an expectation that it would be possible to secure a suitable derogation to allow the GDN to own the equipment. An alternative solution is now being put in place.
6. Predevelopment installation activities	The Basis of Design for the equipment and modifications to the network was developed as part of the Exemption submission. Some early work on the network and services was undertaken where they could be integrated into wider university schedules.

Programme element	Progress
7. Secure project gateway clearances	Internal project gateway clearances were achieved. The key criterion was granting of the Exemption from the HSE. The other requirements were: securing of the necessary planning permission; and the formal agreement by the University Executive Committee. The process was carefully managed to enable Steering Committee sanction the day after the Exemption was granted to expedite project progress, and the consumers were informed the next day.
8. Installation of Hydrogen Injection Equipment	A detailed execution plan has been agreed and this element of the programme is fully underway. The core equipment is on order. The detailed design of the grid entry unit is being undertaken by the supplier. Long lead items for the electrolyser have been placed. Site works are well underway to provide utilities and connections to the grid injection compound which will commence construction in the first quarter of 2019.
9. Installation of Network Monitoring equipment	Detailed plans for network monitoring have been developed. This has been supported by key suppliers who are contributing equipment and advice to the programme. Network monitoring includes sample points strategically located around the network to enable compositional, pressure and temperature data. This will provide confirmation of network gas flows and enable validation of network models. As part of the programme, a dedicated appliance test facility is being established. Four key manufacturers are each providing two fully instrumented boilers which will be installed in a strategically located university boiler house such that they can operated on natural gas and a blend respectively. Based on duty cycles selected by the manufacturers to represent accelerated life time tests, they will be operated and monitored for the entire trial phase. Following the trial these will be stripped down and 'blind' assessed by the manufacturers without knowing which of their units was operated on a blend. This will provide ground breaking evidence of blend operation to support long term deployment.

Programme element	Progress
10. Pre-Injection processes	The processes were agreed as part of the Exemption and detailed operational plans are being finalised. Further pre-trial tests of installations and network will be undertaken to ensure that the gas safe position is maintained and that a clear reference is developed against which the trial phase can be benchmarked. A training programme has been developed and will be implemented in 2019 for all operatives and other stakeholders in the delivery of the trial phase. This ensures that the revised procedures for the trial, including changes to gas detection are fully implemented. Even where no changes are required by individuals, this will provide necessary familiarisation. Gas appliance manufacturers and service providers will also participate, ensuring that service engineers and technical departments are fully briefed.
11. Injection plant and equipment operation	Not scheduled to commence until 2019.
12. Data gathering during the trial	Not scheduled to commence until 2019.
13. Incremental Injection	Not scheduled to commence until 2019.
14. Plan follow-up project on public network	Based on the extensive understanding developed in the HyDeploy programme at Keele, the plans for the public trials were developed. HyDeploy2 successfully secured funding and will commence in April 2019.
15. Keele Site reinstatement/ Handover	Not scheduled to commence until 2020.

Programme element	Progress
16. Dissemination and reporting	The project held a formal launch event in February 2018, which despite the weather was well attended, with a keynote given by Sir Ed Davey, former Energy secretary of State for Energy. The project has been presented at a range of events during this period including those organised by the HSE, the Knowledge Transfer Network, IGEM and others. At the request of BEIS, the project was presented at COP24, the UN Climate Change Conference, as an example of UK projects showing leadership in delivering practical carbon savings. A number of technical papers are under development to disseminate the findings from the Exemption process and a technical workshop is planned for early 2019. The Advisory board has now convened three times, facilitating direct engagement with both national and international stakeholders. The frequency has increased at the request of the board given UK policy makers focus on heat solutions. Public Press Statements were released on the granting of the Exemption.
17. Project Management	Effective project management is necessary to deliver a project with 6 partners and multiple work streams. The governance structure is provided by the Steering group which meets quarterly. A well-managed system of monthly project meetings with associated programme and budget reporting is in place, and a comprehensive project risk register being used to manage the programme. Subsidiary working groups monitor and progress individual work streams.

5.0 Progress against budget

The table opposite shows the progress against budget to the end of October 2018. The programme is being managed for overall delivery within budget.

The complex and extensive scientific programme associated with the Exemption submission required a greater level of effort than originally anticipated. Some rebalancing of the scientific effort across the programme has enabled this to be addressed. As flagged in the previous progress report, the Grid Entry Unit will be more expensive than anticipated. The overall budget is being managed to accommodate this, but continues to be an area of focus through the build programme. One of the key mitigants has been collaborative work with manufacturers and suppliers relating to the experimental programme to offset costs. The spend shown on equipment installation is lower than the planned budget to date due to the slight delay; following internal project sanction to phase in November, committed costs are higher.

Inevitably individual programme elements will vary compared with budget, but this is being actively managed with a process of monthly reporting and review, enabling proactive decisions to be made to deliver the project to plan.

Overall, the programme is being managed for delivery within budget.

Programme element	Spend to date (£)	Budget to date (£)	Total budget (£)
1. Site Communications and stakeholder engagement	232,418	226,307	266,893
2. Activities to develop Exemption	1,831,285	1,470,340	1,470,340
3. Specification and design of H2 Production & Entry Units	329,639	231,912	231,912
4. Write safety case and apply for Exemption.	119,452	117,081	117,081
5. Regulatory and billing arrangements	16,490	175,656	175,656
6. Predevelopment installation activities	97,653	125,501	125,501
7. Secure project gateway clearances	120,420	213,940	213,940
8. Installation of Hydrogen Injection Equipment	94,218	1,065,446	1,909,931
9. Installation of Network Monitoring equipment	15,862	299,451	462,045
10. Pre-Injection processes	1,146	3,875	67,264
11. Injection plant & equipment operation	-	-	362,776
12. Data gathering during the trial	-	-	285,330
13. Incremental Injection	-	-	219,724
14. Plan follow-up project on public network.	10,175	-	95,428
15. Keele Site reinstatement / handover	-	-	135,013
16. Dissemination and reporting	99,509	166,727	341,636
17. Project Management	507,324	484,159	781,117
Total	**3,475,591**	**4,580,396**	**7,261,586**

The purpose of this project is to deliver a non-disruptive low carbon solution for customers.

6.0 Project bank account

Bank statements have been provided to Ofgem. Due to the confidential nature of the project bank statements, they have not been included in this report.

7.0 Successful delivery reward criteria

All scheduled Successful Delivery Reward Criteria were completed in full during this period, as tabulated below and as evidenced to OFGEM.

SDRC1: Communications plan
24th November 2017

SDRC2: Laboratory Appliance Tests
30th March 2018

SDRC3: Onsite Survey programme
25th May 2018

SDRC4: Exemption Submission
30th June 2018

SDRC5: HSE granting of Exemption
1st November 2018

SDRC6: Transition to Phase 2
1st November 2018

SDRCs 1 to 4 were all completed on time. There was a slight delay to SDRC 5 and 6, with a slightly later submission and a longer determination of the complex Exemption than originally anticipated. The SDRC due for completion over the next period is SDRC7, installation of the hydrogen production & Injection system.

8.0 Data access details

No public network or consumption data has been collected on this project to date.

9.0 Learning outcomes

The following key learning points have been identified during this period, and provided the foundation for delivery of the ongoing programme, as well as informing the approach to be taken for HyDeploy2. These have been broken down into specific programme areas.

Overall Technical Programme.
The programme has delivered a comprehensive case for an Exemption to GSMR at 20%$_{mol}$ hydrogen. A key lesson learned has been the focus of much of the work has been to ensure that the evidence for 'no change' is robust. This is often more arduous than justifying a specified change.

Quantitative Risk Assessment (QRA).
This is central to the Exemption. A detailed 200+ gate/event QRA has been developed, benchmarked against historic GB gas network experience. It has demonstrated that Keele University is a particularly safe network and provided the evidence that with limited, minimally disruptive mitigation measures operation of a blend does not prejudice the safety of the gas consumer, which the HSE are opining on. Lessons learned:

- The structure of the QRA is considerably more sophisticated than originally anticipated,
- Securing coherent and consistent data from the wider gas industry can be challenging.
- Robustly translating the core scientific findings into quantitative data to input into events and gates is arduous.
- At Keele it is possible to take conservative positions on inputs, for example where the evidence base is currently more limited. This can be compensated with specific mitigation measures, given Keele's site and the available controls.
- For public network operation the evidence base needs to be extended, such that the assessments of risk can be more precisely drawn, requiring less conservatism. This is necessary since fewer specific measures can be put in place.

Customer Engagement.
At Keele, the project achieved very good customer engagement. The team had a dedicated customer liaison member of staff who was passionate about the project and about addressing customer needs. Feedback was positive and good access was achieved. Lessons learned:

- Don't underestimate the time and effort to communicate with customers. It is the critical few that require the majority of the attention.
- Issues that arise are often nothing to do with the project itself.
- Timing of engagement is important for customers.

Supply Chain Engagement.
The project has benefited from excellent support from appliance manufacturers who have provided time and equipment. Lessons learned:

- Collaborative workshops provide a valuable means to engage & share information.

Procedures.
A comprehensive set of detailed procedures have been reviewed and assessed for the Exemption application. Lessons learned:

- As anticipated, the outturn changes to procedures are relatively limited. However, demonstrating that existing procedures are safe and suitable is a considerable task even if the final outcome does not appear significantly different.
- A collaborative forum of operational knowledge combined with analytical science is invaluable.

Equipment Development.
Detailed designs have been developed for the hydrogen production and first of a kind injection equipment, as well the installation. An effective tender process was undertaken for the injection unit with good working relationship with the supplier, building on Biomethane entry unit experience. Lessons learned:

- The annual gas network demand profile is a challenging duty.
- The practicalities of installation and detailed service provisions can present unexpected schedule and cost issues.

Regulatory.
An approach to billing has been agreed in principle, but securing a simple solution to ownership of the electrolyser from a regulatory perspective has proved challenging. Lessons learned:

- Finding workable solutions to regulatory issues is complex and time intensive.

Team and Project Delivery.
The team is well formulated, complementary and is delivering high quality work effectively. Lessons learned:

- Combing scientific rigour with practical experience is extremely valuable.
- Communicating assessments of complex risk profiles effectively through organisations is important.
- Internal project reporting processes provide visibility to enable informed decisions, particularly when managing the budgets of development projects.
- Engagement with other projects enables sharing of information and best practice, avoiding duplication and improving outcomes.

10.0 Intellectual property rights

No registrable IPR has arisen during the period.

The team is well formulated, complementary and is delivering high quality work effectively.

11.0 Risk management

Effective risk management is critical for successful project delivery. A risk register is being used as a project management tool.

Many of the key project delivery risks have been successfully addressed over the last year. The submission and determination of the Exemption would not have been achieved had this not been the case. This includes in particular customer engagement risks, risks associated with support from appliance manufacturers, risks associated with developing equipment designed to deliver the blend, as well as the myriad of individual risks associated with the ability to secure the necessary evidence base.

The key identified risks being managed going forward are:

Programme Construction Risks.
Now that the project is entering this phase, many conventional construction risks need to be managed. First and foremost, this must be delivered safely under CDM regulations. Delivering a construction programme within the refined budget and to schedule requires careful management, and a well-defined execution plan.

Regulatory Risks.
It has not been possible to secure a derogation to enable the Gas Distribution Network Operator to own the hydrogen production plant. An alternative solution is being implemented, but this remains a risk being managed.

Implementation of agreed operational procedures.
As the project enters the operational phase, it is critical that the operational procedures agreed with the HSE are fully implemented. This is being undertaken through the development of an extensive training programme which will be piloted early in 2019 in order to roll out ahead of first injection.

Business as usual risks.
Whilst the project is focused on delivering a blend of natural gas and hydrogen blend onto a UK network for the first time, much of the activities are 'business as usual' for gas networks. Both Keele University and GDNs remain focused and vigilant to ensure that the network continues to operate safely as usual as we approach and then deliver the trial phase.

12.0 Accuracy assurance statement

This report has been prepared in accordance with the Gas Network Innovation Competition Governance Document published by Ofgem. The project has been subject to review and challenge by the Cadent Project Manager and signed off by Damien Hawke, Cadent Safety & Network Strategy, who is Project Sponsor for this NIC project.

Damien Hawke has confirmed that the processes in place and steps taken to prepare this Project Progress Report are sufficiently robust, and that the information provided is accurate and complete.

Whilst the project is focused on delivering a blend of natural gas and hydrogen into a UK network for the first time, many of the activities are 'business as usual' for gas networks.

If hydrogen were blended at 20%$_{mol}$ with natural gas across the UK, it would save around 6 million tonnes of carbon dioxide emissions every year, the equivalent of taking 2.5 million cars off the road.

13.0 The project team

HyDeploy is being delivered by the HyDeploy consortium, which has technical expertise and practical experience. The partners are:

Cadent Gas (formerly National Grid Gas Distribution) is leading HyDeploy. They own and operate four of the eight gas distribution networks in the UK, including the West Midlands.

Keele University is hosting HyDeploy on its campus and the University's Materials Department are carrying out research on the impact of hydrogen on materials.

ITM Power manufacture integrated hydrogen energy solutions. They will be supplying the hydrogen production unit for HyDeploy.

Northern Gas Networks is partnered with Cadent to deliver HyDeploy. The project supports their other work exploring the future role of gas. They own and operate the gas network in the North East, Northern Cumbria and much of Yorkshire.

Health & Safety Laboratory is the scientific arm of the Health & Safety Executive. They will be providing the scientific evidence which will support the safety case for the trial.

Progressive Energy is an independent UK clean energy company. It will be supporting the management of HyDeploy through development and implementation.

In addition to the core project partners the project is supported by a number of key companies:

Kiwa – Specialise in gas testing. It is carrying out offsite testing on a range of common household appliances to inform the project, and will lead the gas safety appliance checks on the campus.

Dave Lander - is an internationally recognised expert in gas quality and safety and is co-ordinating the Exemption application to the HSE.

Otto Simon Limited – are an engineering consultancy and project delivery organisation, responsible for the installation of hydrogen equipment onsite.

HyDeploy

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