RIIO|GD1

Our Innovation Strategy

National Grid
Gas Distribution

April 2012

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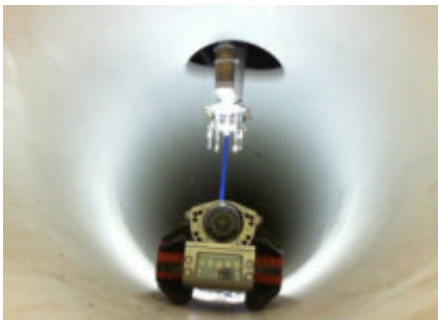
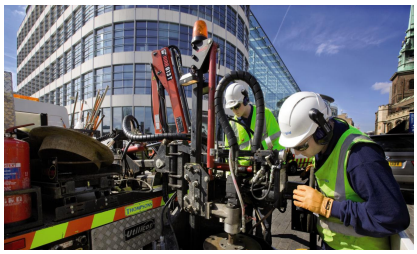


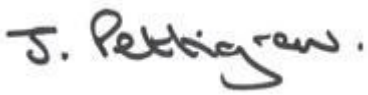


***Clockwise from top-left**:*
PE Pipe Profiler, Beam Drilling, Pipehandler, Biomethane (Adnams), Rapid Service Cut-Off Tool, Keyhole Technology

Contents

Key Messages

- Innovation is at the heart of our plans for the future. Our RIIO-GD1 Innovation Strategy document is, therefore, an important milestone for us. I am delighted to be able to introduce the document and to support this essential element of our business plan.
- Our Innovation Strategy supports both our vision and the key strategic principles that are outlined in the new RIIO-GD1 framework. More specifically, it sets out how we are going to move to a new low carbon economy and meet our emission targets, while making sure our energy supplies are safe, secure, reliable and good long-term value for consumers.
- We should not however under-estimate the challenges that we face in the RIIO period - or how we will evolve in response to them - and so we welcome the enhanced level of innovation funding that is available during RIIO-GD1.
- I look forward to Gas Distribution developing into a more innovative organisation to help improve our performance and deliver exceptional services to customers. It is essential that we develop a more innovative culture. Only by doing that will we be able to inspire projects that improve the way we operate and deliver year-on-year efficiencies.
- Equally, we are committed to working together more closely as a business. In particular, we are looking at new ways of collaborating with both our supply chain partners and other network operators.
- As a result, we welcome the new RIIO-GD1 Innovation Stimulus Package, which will embed and encourage innovation throughout the business and the wider industry.



John Pettigrew

Chief Operating Officer

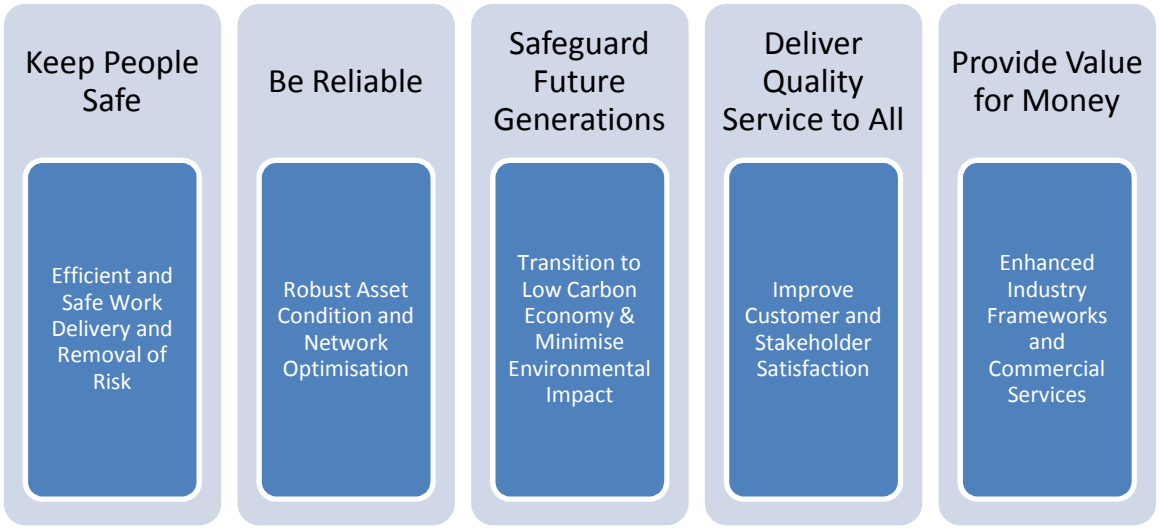
Gas Distribution

Section 1: Introduction

1.1 Our approach is to embed a culture of innovation in everything we do and we will aim to continuously improve our business, through both technical and commercial innovation. This helps us develop our knowledge to provide a safe, efficient and reliable network, which delivers value to our customers and safeguards our environment.

1.2 We will seek innovative solutions to both operational and asset management challenges whilst advancing research into longer term strategic opportunities aligned to National Grid's company vision. We will also leverage third party innovation, share experience and knowledge and actively collaborate with external organisations including other network operators.

1.3 In developing our Innovation Strategy, we consulted widely with our Stakeholders who provided us with some invaluable insights into where we should focus our efforts in light of the challenges we face. Stakeholders told us that Innovation would be vital to meet these challenges and that the following innovation themes, aligned to our five key priorities, were 'sensible and wide ranging' although specifically asked to be open and transparent around our innovation activities.



1.4 Our Innovation Strategy takes into account the new and significant challenges that we will face during RIIO-GD1 and describes our business processes for prioritising our innovative activities during RIIO-GD1. We believe that these processes will help to ensure that the Network Innovation Allowance is utilised effectively whilst maintaining a focus on delivering value for money.

Section 2: Evolution of GDPCR1 Innovation

Introduction

2.1 Historically, we have driven substantial savings and efficiencies in our organisation as a direct result of our innovative activities, which includes taking a lead industry role on a number of collaborative projects. We intend to increase the intensity and scope of our innovative activity during RIIO-GD1 and beyond.

Our Role in Industry Innovation

2.2 We have used innovation successfully to support our ambition on leading the exploration of the role of gas in the energy pathways for a low carbon future as well as facilitating renewable gas into the network through biogas demonstration plants. We have led 6 out of 9 jointly GDN commissioned projects and we are the only company who has collaborated with GERG (the European Gas Research Group).

2.3 In partnership with Adnams Bioenergy, we created the first purpose-built biomethane to grid plant in the UK, which will generate enough energy to heat 235 family homes per year or run an average family car for 4 million miles. In the future, the facility will produce enough renewable gas to power the Adnams brewery and run its fleet of lorries, while still leaving up to 60 per cent of the output for injection into our East of England network.

2.4 We have also used innovation successfully in our core work delivery processes through development and implementation of keyhole technology (see Annex 2: Keyhole Technology). Keyhole reduces excavations and the volume of reinstatement, reducing traffic congestion especially in London and provided an alternative solution to the Olympic project challenges.

Innovation Funding Incentive

2.5 The challenge we set ourselves was to utilise the Innovation Funding Incentive for Sustainable Development (IFI) to support future delivery and culturally re-energise technical research and development in our organisation.

2.6 Without the focus on IFI there was a danger that research associated with the provision of safe, reliable and secure networks would have significantly declined as it did following privatisation during the early 90's. It has been a long journey to re-establish research and development as a valuable core business process.

2.7 We assess the benefits of our IFI projects against:

- Reduced Direct Costs e.g. through reduced planned capital expenditure, maintenance expenditure or efficient operations.
- Avoided Costs e.g. deferred investment, reduced failures, establishing conditions of equipment to feed capital or maintenance plans and improved ratings.
- Enhanced Risk Management e.g. understanding the application of new technology and minimising the impact of our networks on the environment.

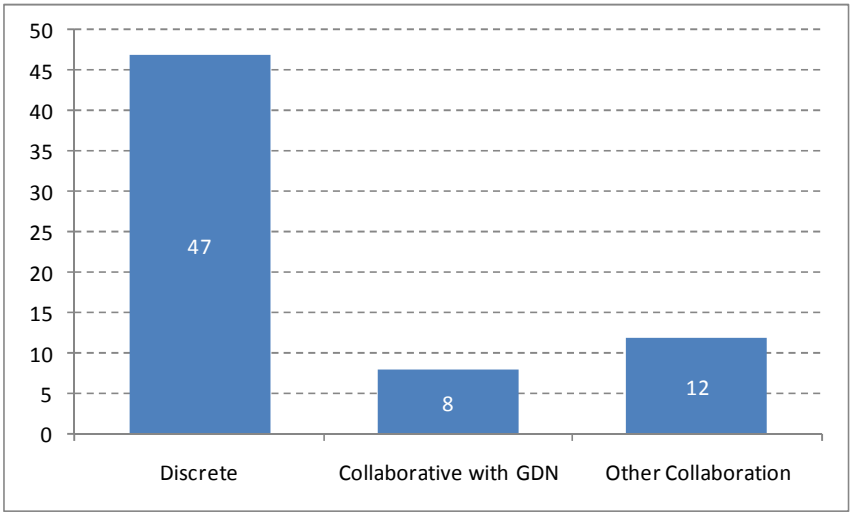
- Strategic Knowledge e.g. working with others to address sustainability in the energy industry, maintaining awareness of new technology in the industry.

IFI Projects Activity

2.8 In the three years since IFI commenced, we have commissioned 67 innovation projects. Approximately 30% of projects commissioned to date have secured funding via collaborative partnership with various other organisations. The projects covered a wide spectrum of gas distribution activities with predominately short to medium term delivery horizons and at various stages in the innovation project life cycle (Annex 3: Technology Readiness Levels).

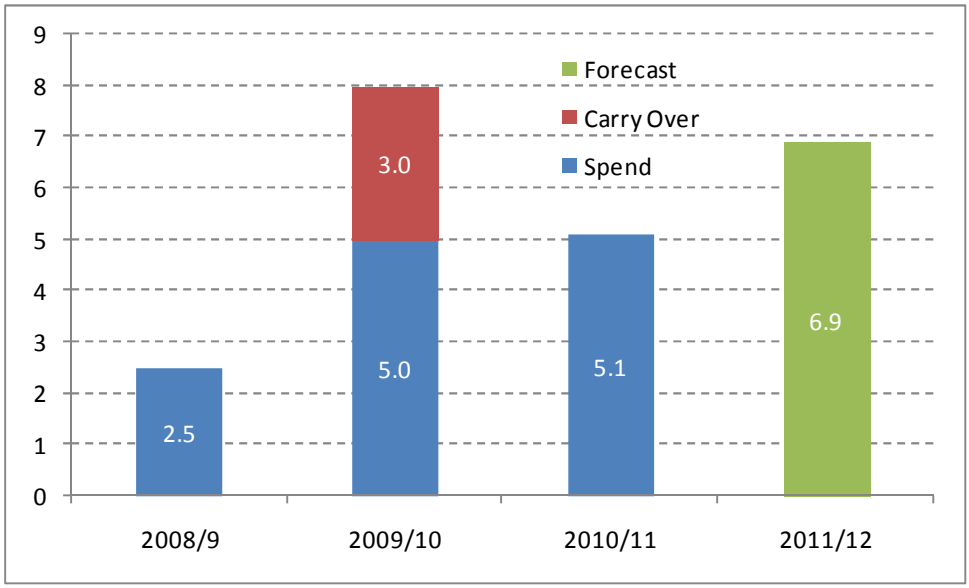
- Number of IFI projects commissioned between 2008/09 and 2010/11:

Figure 2.1 - IFI projects commissioned 2008/9-2010/11 (number)



- Total expenditure over the three years of £15.6m, breakdown as follows:

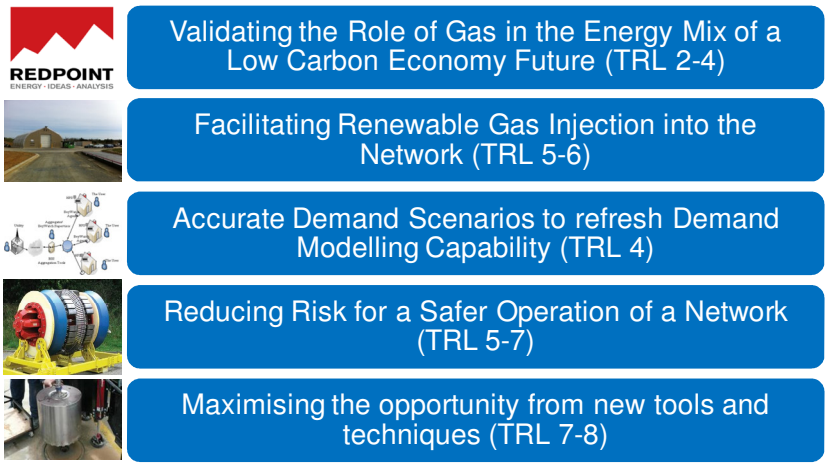
Figure 2.2 - Expenditure (£m)



2.9 The establishment of IFI in 2008/09 meant we had to start to build a new culture of Innovation within our business. Our approach to innovation is continuing to evolve and we are starting to see a steady increase in the IFI expenditure, with associated benefits.

2.10 The following highlights the broad range of challenges that currently make up our 2010/11 innovation portfolio, which are all at different phases of development and technical maturity.

Figure 2.3 - Challenges within our Innovation portfolio



Internal Research and Development (Non-IFI Funded)

2.11 Although IFI has been an excellent incentive to re-energise our Research and Development (R&D) activities, we have also continued to fund Innovation directly from our business, which has ranged between £2.3m and £3.3m per annum (excluding major projects).

2.12 We have run a number of field trials throughout our network, using our own field force, on smaller tools and products to aid efficiency in replacement repair. We have also used our own resources to make improvements to our network analysis, planning tools and connection processes to accommodate biogas connections in the future.

2.13 Our intent is to continue to fund innovation from directly within our business as well as utilise the innovation funding opportunity available under RIIO-GD1.

Section 3: Stakeholder Engagement

Our Stakeholder Journey

3.1 Stakeholders are at the heart of our RIIO-GD1 business plan, and we have embarked on a comprehensive journey of engaging with our Stakeholders to enable us to understand what is important to them. The following summarises the Stakeholder feedback we have received to date:

Talking Networks Events (Stage 2) - May 2011

3.2 As part of our engagement process, we were keen to understand what partnering opportunities there are, and how we can continue to work together with our stakeholders to develop innovative solutions to the challenges that the industry faces. In addition, we asked stakeholders to give us their views on areas of innovation under six broad headings - Safety, Reliability, Environment, Social Obligations, Customer and Connections.

3.3 Our stakeholders confirmed that they were keen for us to involve them at an early stage of innovative developments and suggested mini workshops be held that involve both a range of smaller and larger organisations so that we can be as inclusive as possible. Stakeholders were also keen for us to avoid barriers to partnerships and innovation being established.

3.4 Some stakeholders suggested that we could learn from other sectors and industries, particularly in terms of asset replacement and management. In particular they were keen for us to further explore new non obstructive methods of mains and service replacement, process innovation to minimise time on the highway, and joint ventures between utilities in managing streetworks costs. As part of our consumer focus group research, consumers also raised the possibility of developing a postcode database, so consumers can have easy access to real time streetworks activity.

3.5 On our theme of facilitating a low carbon economy, stakeholders also suggested more generation of electricity from bio-gas (anaerobic digestion), and use of natural gas vehicles. It was acknowledged that our carbon footprint is seen as important, but it has been suggested that the main focus should be around facilitating alternative sources of renewable gas, and looking for opportunities to connect at least cost.

3.6 We also consulted with stakeholders on ways to improving leakage and shrinkage reduction with a range of ideas being suggested around: better joining techniques for mains replacement, pipe lining where practicable, reduction and/or alternatives to venting, and implementing new detection methods.

3.7 Safety also featured prominently, in relation to carbon monoxide, including use of equipment for detection and odourising CO.

SBGI Event - September 2011

3.9 In September we held a specific Innovation related session with SBGI, where we provided an overview of our current innovation activity and highlighted the challenges we believe we face during RIIO-GD1 and hence our proposed areas of focus.

3.10 During the working session, SBGI members gave us valuable feedback and highlighted concerns that there is no clear route to allow suppliers to promote new products and ideas and that our internal processes could have the potential to stifle innovation as the approval process seems slow.

3.11 This group also raised concerns around collaboration / transparency and were very keen for us to develop either an innovation portal or a specific forum to generate and develop ideas as well as providing visibility on project progression and spend.

Talking Networks Events (Stage 3) - September 2011

3.12 Building on our previous engagement, this event specifically focussed on just four RIIO-GD1 topics, one of which was innovation. There was widespread recognition of the need for innovation and agreement that our themes were appropriate however, Stakeholders were keen that we focus on timely and efficient implementation.

3.13 Stakeholders highlighted some key areas of focus for us: improving industry collaboration, asset condition and protection, leakage identification, demand forecasting and efficient and safe working.

3.14 Stakeholders were also supportive of us making the case for an enhanced allowance with general agreement that 0.5% was a small amount and may be a block to effective innovation. This was however caveated with the need to be more transparent on spend areas and being clear on customer benefits for proven innovation prior to roll out.

3.15 Finally, this group were also keen for our processes to be more collaborative which can maximise the expertise of suppliers

Talking Networks Events (Stage 4) - December 2011

3.16 These regional events gave stakeholders an opportunity to have a round table discussion on Innovation. The feedback that collaboration with other utilities is significant during RIIO-GD1 was raised again but also some more focussed feedback that Innovation really matters in London and there is a specific need to innovate to minimise disruption. Stakeholders also shared with us a number of specific ideas for future innovative projects with us, which we will assess to ensure that they would deliver benefit to our customers.

3.17 This extensive Innovation engagement with Stakeholders has not only helped us to identify the main challenges that are likely to face us during RIIO-GD1 but also suggested ways to improve industry collaboration, which we intend to address. We intend to continue working with all stakeholder groups during RIIO-GD1 to develop ideas further as we progress our innovation strategy.

Section 4: Innovation Funding

Utilisation of Innovation Stimulus Package

4.1 We are fully supportive of the RIIO-GD1 Innovation Stimulus Package and believe that it provides the appropriate mechanism and incentive to encourage all GDNs to drive innovation. The following sets out how we intend to utilise the RIIO-GD1 Innovation Stimulus Package:

Network Innovation Allowance (NIA)

4.2 A continued and basic level of innovation funding is required to address the industry challenges that we faced during GDPCR1 and will continue to face during RIIO-GD1. The following highlights these **areas of innovation** which will be consistent across all GDNs:

- Mains replacement technology and techniques to minimise risk associated with our iron mains and multi occupancy building service risers.
- Asset health monitoring capability, more automated network control processes and optimisation of capacity at our existing assets.
- Understanding customer behaviour as a result of the changing energy landscape and the associated impact this will have on the way we operate our networks[1].
- Improvement in the resilience of our assets due to the effects and consequences of climate change.
- Minimise our Business Carbon Footprint emissions, specifically the mitigation of leakage from our above ground assets and pipelines.

4.3 The areas above have been the subject of focus during GDPCR1 and will continue to be so during RIIO-GD1.

4.4 We do however see a need for an enhanced level of innovation funding to address a number of **new and significant challenges** that we will face during RIIO-GD1:

- Firstly, we face increasing pressure to **minimise impact of congestion and Streetworks legislation** (aligned to our Innovation Theme of Efficient and Safe Work Delivery and Removal of Risk). We have received explicit feedback from our stakeholders that there is a specific need to enhance our approach to the management of streetworks activities. This includes more proactive collaboration with other utilities, evolving and adapting our planning and delivery processes to minimise congestion in the street and to minimise streetworks legislation related costs to gas customers. This extends to the need to find alternative methods to deliver our work that avoids the need for disruptive streetworks or minimises the time we are in the street. This is discussed further in the next paragraph. If

[1] We have received 72 initial enquiries for new entry bio-gas connections since July 2011, 7 of which have progressed to Detailed Analysis Study (DAS) stage

successful, customers would see the benefits of lesser disruption and lower overall utility costs.

- Secondly, we need to find the optimal delivery approach to our **London Medium Pressure (MP) replacement strategy** (aligned to our Innovation Theme of *Asset Condition and Network Optimisation*). Our London MP replacement strategy sees us working in the nation's capital city over the next two decades representing significant engineering, planning and operational challenges. The need to consider and explore alternative solutions to traditional mains replacement, or improved or lower cost delivery solutions for this major project, if successful, would bring benefits to future customers particularly as this project will be a key part of the RIIO-GD2 period.

- To pursue innovation to support the above two challenges, we will need to **invest in higher risk technologies**. More specifically, we will look to technologies at the early development stages of the Technology Readiness Level (TRL) scale, which by their nature carry a higher risk of evolving into a project. We will explore these technologies to determine if we are able to adopt and drive real efficiencies. Examples of this more high risk technology we would seek to explore would be:

  - Development of Pre-Fracture Warning Systems.
  - Cured in Place pipe.
  - Spray Lining Rehabilitation.
  - Internal Inspection Technology.

- These technologies are described in more detail in Section 5: Themes and Projects. They are all higher risk technologies that seek solutions that will enable asset condition to be identified more easily and reduce the requirement to open the road to inspect or remediate the assets. None of these technologies are yet proven and would need significant funding support to test, develop and, if successful, bring to implementation.

- A third area that we believe needs further innovation focus is **commercial innovation** (aligned to our Innovation Theme of Enhanced Industry Frameworks and Commercial Services). Our stakeholders have told us they wish us to do more to help the industry and market processes function better for example in areas such as theft of gas, use of smart metering technology and capacity products at the NTS / DN boundary. We see a need to explore commercial and partnership solutions to these issues by working with our stakeholders and developing market and contractual solutions to these cross industry issues.

- An enhanced level of Network Innovation Allowance (NIA) funding would be diverted towards these three challenges. As shown in Annex 6: Projected Utilisation of NIA, we are proposing to utilise a significant proportion of our NIA funding over RIIO-GD1 to address these three challenges.

- We believe that an enhanced level of funding for these high risk technologies would be a good investment for customers and is a level of innovation ambition that is in line with other industries. Our proposed level of funding is also consistent with the guidance from the government department of Business, Innovation and Skills (BIS) R&D scorecard, which highlights that an applicable level of investment in basic research should be 2.5% per annum for leading companies with innovative utilities investing at least 1%. This requirement is further recognised at a European level with the ENTSO-E R&D group who suggest that 1% of (TSO) annual turnover should be spent on innovation.

Network Innovation Competition (NIC)

4.5 Our approach to the Network Innovation Competition builds upon our innovation work to date and is centred on promoting a transition to an affordable, secure and low Carbon future. We strongly support the development and the demonstration of new technologies that could benefit our customers both in the near and long term, and we are currently developing our plans to progress projects that will generate learning that can be rolled out to the benefit of all GB customers.

4.6 We have a number of 'large scale' projects in mind, which we believe would meet the criteria of the Network Innovation Competition.

4.7 Optimisation of Gas / Electric Smart Grids

- Demonstrate optimisation of gas and electricity networks through dynamic fuel switching to manage heating in the most efficient and economic way. Our work will identify the appropriate appliances for differing parts of the residential market. Where appropriate we will make use of dual fuel boiler technology currently being reviewed under our IFI programme. We aim to pilot the technology to demonstrate the optimisation of heating (dynamic switching) to balance energy demands, minimise heating costs and reduce Carbon emissions. Smart energy systems and controls will be tested as part of the study to evidence the potential benefits of smart metering and integration of existing energy grids. The scale and cost of such a trial is dependant upon scale of the pilot and we aim to discuss the planning of such a trial with our partners in due course.

4.8 CNG / LNG refuelling Network

- We aim to review the potential of establishing a national / regional network of fuelling stations open to the public for refuelling with CNG and LNG. We remain open minded to other fuelling option for other market users as part of this programme such as Hydrogen vehicles (anticipated to be attractive for smaller personal or fleet vehicles). The scale of such a project depends upon the number of fuelling stations developed under the programme.

4.9 Shale gas connection to Local Transmission System

- This area remains the less developed of all areas we have considered to date. However, we believe that should shale gas production become an acceptable method of gas extract there are maybe considerable benefits to connecting such

gas fields into the Local Transmission network. We remain at a very early stage in developing our thinking in this area but believe it would be inappropriate to ignore such potential that may arise over the next decade. We envisage a project to review the operational control, longevity of connection, gas quality and capacity implications of embedded unconventional gas entry points.

4.10 Gasification / Bio-SNG Production and Distribution

- We aim to reduce the technology risks perceived in the process of converting waste material in to grid quality gas. This project aims to carry out a technical demonstration of end-to-end process integration of advanced gasification / bio-SNG production technologies on a commercial scale for gas grid injection. This has the potential to provide a platform for future investment in a fleet of large-scale waste to energy facilities, with a view to substantially de-carbonising future UK gas supplies.

4.11 Hydrogen Injection / Enrichment:

- Working collaboratively across European gas community we aim to review and demonstrate two aspects in the Hydrogen area. Initially we aim to further develop the NaturalHY project and look into potential to use spare wind farm capacity to produce renewable Hydrogen and distribute as part of a Hydrogen Enriched Natural Gas (HENG) blend to customers. The project will assess the concept feasibility and economic analysis of hydrogen injection directly into gas network. Hydrogen enrichment is viewed as a viable option for existing gas customers. However, given we expect that between 2050 and now most customers will have replaced their heating appliances 3 to 4 times, we aim to review the feasibility of 100% Hydrogen distribution and repurposing existing low pressure gas distribution pipeline assets.

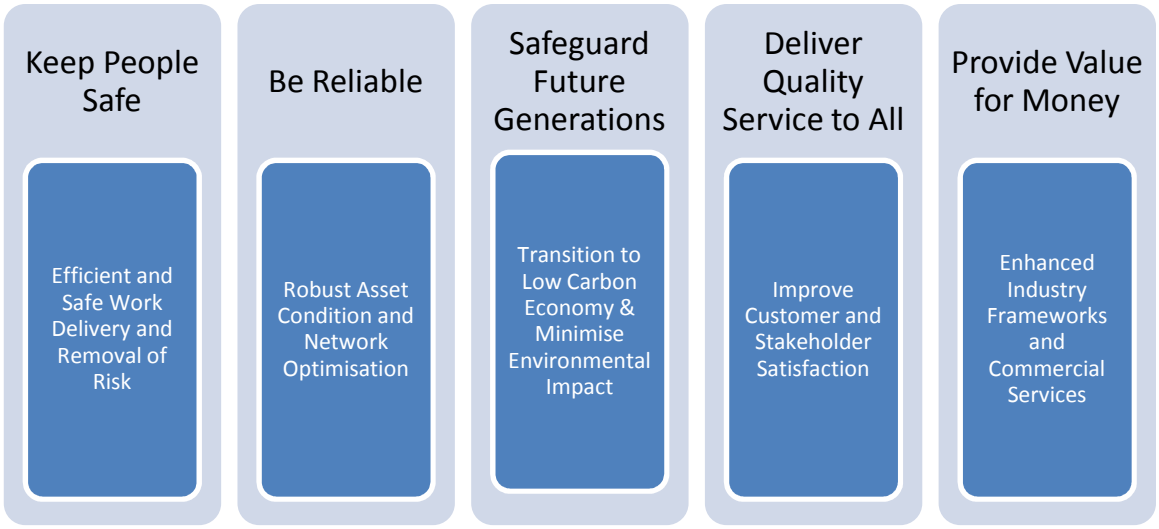
Section 5: Themes and Projects

Innovation Themes

5.1 We have considered our key priorities and developed five innovation themes, which more specifically describe the areas we are seeking to explore.

5.2 The following describes each of our innovation themes in turn and the business challenges that we want to address. We also provide some examples of projects we will consider progressing during RIIO-GD1 and describe how these projects might deliver benefits aligned to our output commitments and how we might measure success of the projects.

Figure 5.1 – RIIO-GD1 Priorities aligned to Innovation Themes



Efficient and Safe Work Delivery and Removal of Risk
~ Keep People Safe

5.3 The main challenge here is the delivery of our new mains replacement programme based on a risk removed approach as opposed to length of iron pipe abandoned and the need to progress the development of improved mains replacement technology and techniques, to minimise risk to be more efficient, safe and less disruption to the public.

Figure 5.2 – Examples of projects aligned to Keeping People Safe

Potential Project Area	*Output Commitment*	*Area of the Business Plan*
Enhanced risk modelling for larger diameter pipes. Cured in Place Pipe (CiPP) linings as an alternative to PE for mains replacement and risers	*Reduce the risk of our iron mains by 55% and deliver customer benefit through our mains replacement programme*	*Asset Management: Replacement*

Minimise use of imported materials for all types of excavation work. Further development of our reinstatement truck to be an effective and efficient solution to recycling onsite materials	*Minimise the impact that our operations have on the environment reducing leakage by 21% and Business Carbon Footprint Emissions 20%*	*Asset Management: Replacement*

Asset Condition and Network Optimisation

~ Be Reliable

5.4 To address challenges related to this theme, we need to ensure that our assets are resilient and can adapt to the consequences of climate change such as incremental hotter, drier summers and warmer, wetter winters coupled with more erratic fluctuations in temperatures, river bed erosion and increasingly frequent extreme weather events such as floods.

5.5 We have also identified a number of specific challenges associated with major cities, specifically London, in terms of consequences of incidents and congestion, specifically the requirements of the Traffic Management Act. We are also being driven towards a step change to improving our processes in respect of asset health and network management.

Figure 5.3 - Examples of projects aligned to Being Reliable

Potential Project Area	*Output Commitment*	*Area of the Business Plan*
Internal pipeline inspection and profiling of mains and joints using tethered and untethered robot technology. Look at non-gas applications of robot technology to enable intelligent pipeline inspection	*Develop our Asset Management approach, carry out 55,154 MOB surveys and deliver a programme to remove risk and improve the health of our key assets*	*Asset Management: Asset Health*
Improve monitoring techniques for above ground and below ground assets through use of nano technology. Wide scale use of such technology has the potential to provide constant feedback on asset performance	*Maintain the performance of key operational assets such as the accuracy of our offtake meter errors and timely response to asset faults*	*Work Delivery: Maintenance*

Transition to Low Carbon Economy & Minimise Environmental Impact

~ Safeguard Future Generations

5.6 The challenges related to this theme are those associated with changing energy landscape and the need for us to transition to a low carbon economy. We will also need to continue our focus on reducing our impact on the environment and the minimisation of our Business Carbon Footprint emissions will remain at the forefront of our innovation activities. In addition, specific Government mandated initiatives will clearly also present us with new challenges such as the mandated roll out of Smart Metering.

Figure 5.4 - Examples of projects aligned to Safeguarding Future Generations

Potential Project Area	*Output Commitment*	*Area of the Business Plan*
Improve leakage detection and minimise gas lost through purging and venting activities. Whilst we have carried out some trialling of technology (under IFI5) this would focus on improving the technology and how to capture and potential re-use lost gas	*Minimise the impact that our operations have on the environment reducing leakage by 21% and Business Carbon Footprint Emissions 20%*	*Asset Management: Shrinkage*
Optimise employee and Fieldforce mobilisation and travel arrangements. Specifically learn from improvements made in other sectors such as introduction of telematics and more supportive home working arrangements	*Minimise the impact that our operations have on the environment reducing leakage by 21% and Business Carbon Footprint Emissions 20%*	*Work Delivery: Resourcing Strategy*

Improve Customer and Stakeholder Satisfaction

~ Deliver Quality Service to All

5.7 During RIIO-GD1, we need to consider more innovative ways to improve the service we deliver to customers such as the challenge to minimise supply losses and getting customers' supply restored as quickly as possible.

Figure 5.5 - Examples of projects aligned to Delivering Quality Service to All

Potential Project Area	*Output Commitment*	*Area of the Business Plan*
Minimise customer disruption as a result of our streetworks activity, manage compliance with streetworks legislation	*Manage the costs and reduce customer disruption associated with Streetworks activities*	*Asset Management & Work Delivery: Streetworks*
Improve communications with customers through development of customer portals to enable work programmes to be viewed with the potential to enable customers to provide feedback directly	*Improve customer satisfaction and complaint handling performance and achieve Upper Quartile performance*	*Work Delivery: Work Management*

Enhanced Industry Frameworks and Commercial Services

~ Provide Value for Money

5.8 We need to consider innovative commercial and regulatory frameworks to help us best manage future uncertainties such as volumes of biomethane connections to our networks. We will also look to develop innovative approaches to solving problems of theft of gas, encourage new capacity products, utilise of smart data and new charging methodologies.

Figure 5.6 - Examples of projects aligned to Providing Value for Money

Potential Project Area	*Output Commitment*	*Area of the Business Plan*
Develop more innovative approaches to facilitate the connection of biomethane and other renewable sources of gas to the network either through contractual arrangements or charging structures	*Take a lead in shaping future energy policy and facilitate sustainable gas resources to connect to our network*	*Asset Management: Connections*
Improve our partnership and supplier contractual arrangements and product sourcing strategies to facilitate collaboration and innovation in order to drive efficiencies for the benefit of stakeholders	*Create enduring engagement forums and improve collaboration with stakeholders*	*Work Delivery: Work Management*

Innovation within our Business Plan

5.9 The following are examples of completed Innovation Funding Incentive (IFI) projects the benefits of which have been factored into our plan:

- Impacts of Flooding on Gas Pipeline and Above Ground Installations (IFI2): Provided knowledge of the flooding risks of our strategic assets such as above 7 bar pipelines and above ground installations as well development of a risk model to reduce the likelihood of loss of supply in the future.
- Impact of Future Energy Systems on Energy Networks – Beywatch (IFI3): This work provided knowledge that has been used to help develop a strategy for energy supply and the optimum development of future energy networks. Results have been used to inform the national debate on energy network futures 40 years and has been presented to both Ofgem and the Department of Energy and Climate Change (DECC). The energy model has been used to model a variety of future energy scenarios decade by decade and help identify issues and opportunities to enhance network development.
- Maximising The Benefits of Keyhole Excavation (IFI11): Further advancements in keyhole technology has led to the development of the beam drilling method the biggest change in 30 years in the procedure for attaching fittings to live metallic mains 4” to 48” and excavations have been reduced to one sixth of the size of conventional excavation.
- Demonstration Trial for On-site Energy Savings (IFI45): Trialled new energy saving devices on three of our office sites with a resultant 10% reduction in electricity use reduction was achieved with an associated saving of 115 tonnes of carbon dioxide.

- Human Factors in Gas Operations (IFI49): The knowledge associated with the implications of human factors in decision-making were reviewed within the maintenance functions, within Operations, to inform GDFO[2] design.

- Work Scheduling and Mobile Solution in the Field (IFI56): The innovative integration of work scheduling software 'CLICK' and mobile solution 'SYCLO' will improve the operation and maintenance of the network by ensuring both labour, plant and equipment resources are optimised.

5.10 In addition and in support of our London medium pressure strategy, we have assumed the successful completion of the following project:

- New Materials for Gas Distribution (IFI51): Research and development shows that it is now more likely to lay large diameter polyethylene (PE) pipe in urban areas (>630mm) between 1-3 metres of the building line. The potential outcome of this project has been factored into the London MP strategy.

Ongoing Innovation

5.11 These IFI projects have gone through a process of assessment and rationalisation to ensure that they are aligned to deliver value to customers under RIIO-GD1, and we should continue to explore further. We have not assumed any significant benefits from these initiatives at this stage, as they may not prove technologically viable or economic to deploy. We are hopeful that some will prove successful for implementation to underpin delivery of our plan and help us to deliver our efficiency targets.

- Optimise Own Energy Use (IFI4): The new technologies on trial offer improved environmental, integrity and cost effective performance over water bath heaters. Current water bath heater replacement systems (modular boilers with heat exchangers) do however require contingency arrangements, in the form of backup modular boilers and heat exchanger, and need to be maintained and notably require an electricity supply. If these trials are successful then efficiencies can be made on alternative replacement technologies.

- Reduction in Methane Losses (IFI5): Research to date has delivered a decision support tool that allows site assessment to be undertaken to provide optimum ways to reduce leakage. During the RIIO-GD1 period, we will further develop this project and continue to explore potential future solutions for effective leakage management.

- Risk Based Automatic Handling of Plant Enquiries (IFI7): An intelligent web based enquiry system, incorporating damage prevention management procedures and automated responses for individuals to carry out third party work near our assets, has been developed and implemented internally. This has improved the speed of customer responses and efficiencies in the plant protection team.

- Better Load Analysis & Demand Modelling - Feasibility (IFI19): The principle benefit from this work at this stage will be knowledge that may ultimately lead to

[2] Gas Distribution Front Office

the production and replacement of the current published demand algorithms that will be appropriate for implementation. Better identification of demand requirements into the future could lead to better targeted and timely reinforcement and replacement planning of the networks and better understanding of peak condition.

- Alternative Sources/Scenarios for Bio-methane Injection (IFI47): Develop knowledge of best industry practice on the injection of biomethane into the grid in the UK for the pressure tiers identified. This project should also identify any on-going barriers that may prevent biogas being injected and reaching its full potential.

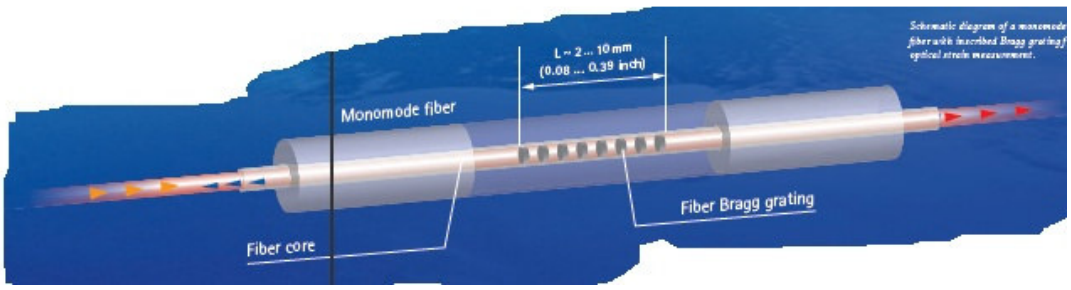
- Asset Health Modelling (IFI76): Condition Based Risk Management (CBRM) is essentially a process that is based on utilising asset information and assessment of risk to support policy and strategic decisions. The CBRM tool will allow the future Health Index (HI) and Probability of Failure (POF) of assets to be simulated and assessed. This will allow the effort of replacement, refurbishment or changes of maintenance regimes to be modelled resulting in the recalculation of the POF, Consequence of Failure (COF) and Risk.

New Areas of Innovation

5.12 We are looking to progress these projects in order to meet the new challenges we will face during RIIO-GD1, which will also provide justification for an enhanced level of funding:

- Pre-Fracture Warning System Using Strain Gauge Technology: We are proposing to attach strain-gauges to some of our Tier 3 cast iron pipes which will potentially provide us with a remote alarm where excessive strain is observed. If proved successful we would get a warning that a pipe is in imminent danger of fracture failure. Optical strain gauges are made from fibres of glass with a very small core diameter (0.0025mm -less than the diameter of a human hair). The diagram below shows an enhanced view of the make-up of the cable:

Figure 5.7 - Enhanced view of optical strain gauge cable



- Pre-Fracture Warning System Using Electro-Magnetic Induction: The technique also has the potential to predict fracture failure in cast iron pipes. An electro-magnetic field is induced to the iron pipe structure, and any variation in the returned signal would indicate a flaw at to either the interior or exterior pipe wall. This system would also be able to transmit information direct from the field to our central control room.

- Cured in Place Pipe (CIPP): CIPP is a technique whereby the host pipe is lined with a flexible tube which is impregnated with a thermosetting resin, which produces a tough pipe lining once the resin has cured by the use of heat or UV light. CIPP is a much cheaper alternative to replacement with PE, as liners can be inserted to around 150m each way from the point of launching without excavation.
- Spray Lining Rehabilitation: Spray-lining is a technique whereby a host pipe is lined by spraying a thin layer of material onto its internal surface - initially cement mortar was used, then epoxy resin, and more recently, polyurethane (PU) materials have been used. The technique is established in other Utilities but has not been previously utilised in the UK gas industry. A specific area to address is around future connectivity, long term performance of the liner materials, and whether the integrity of the liner will be adversely affected in the event of a future fracture failure of the parent main.
- Internal Inspection Technology: Internal Inspection vehicles (or PIGs – Pipeline Inspection Gauge) have been used in various guises for some time in the UK gas industry. Modern intelligent PIG's are highly sophisticated instruments that vary in technology and complexity, incorporating electronics and sensors that collect various forms of data during its journey through the pipeline that provide an accurate assessment of the condition of the pipe. During RIIO-GD1 we intend to revisit this technology for our Tier-3 pipes, as confirmation that wall thickness reduction levels are not significant would provide us with some comfort that the pipe is not in danger of imminent fracture failure. An example of an Intelligent PIG is shown below:

Figure 5.8 - Intelligent Pipeline Inspection Gauge (PIG)

Section 6: Prioritisation of Innovation

6.1 We have described in Section 4: Innovation Funding how innovation can help us to solve some key challenges during RIIO-GD1. The following criteria will help us to set out how we will prioritise our innovation investment to address these challenges

- Value: assessment of the potential value to customers over the short and long term, combined with
- Likelihood: likelihood of success, both from a conceptual perspective and the ability and ease of implementation, and
- Size: the size of the project (large or small) to test the risk balance of our investment portfolio.

6.2 We have a robust governance process surrounding the innovation investment process. At a broad programme level, we will have a clear Innovation Strategy that will be reviewed on an annual basis by our senior leadership. This strategy will clearly set out the priorities for the year(s) ahead based on how we intend to deliver value to consumers whilst balancing our portfolio of innovation projects against our five key RIIO-GD1 priorities and innovation themes.

6.3 At a broad programme level, we will have a clear Innovation Strategy that which will be reviewed on an annual basis by our senior leadership. The strategy will clearly set out the priorities for the year(s) ahead based on both in terms of how we intend to deliver value to consumers whilst balancing our portfolio against our five key priorities. Our value drivers will be aligned to those significant spend areas within our Business Plan such as our mains replacement, asset health and resource optimisation.

6.4 A central team will oversee the resultant innovation programme to ensure priorities are met, value is delivered to customers and to challenge the gas distribution business to trial and test new concepts. The team will also coordinate the relevant sanctioning committees to ensure robust governance, oversee contract processes with suppliers and coordinate the sharing of knowledge and management of ideas.

6.5 Our intent is that the strategy (both the programme view and the individual project assessment) will then be monitored on a quarterly basis by a senior committee and governed monthly via Distribution Innovation Governance Group (DIGG) where senior representation from all gas distribution will be present.

6.6 At a project level, we will ensure they meet the NIA relevant criteria (yet to be agreed) as well as our five key priorities. We will also ensure that for each project there will be appropriate challenge and review to ensure eligibility judged against a number of additional criteria, including assessment of benefits that the innovation is expected to deliver. We will adopt the balanced scorecard approach[3] to evaluate the benefits of innovation that will include those wider non-financial measures such as safety and sustainability.

[3] Aligned with the Gas Distribution IFI/SD Good Practice Guide – December 2008

6.7 We will use the best available information at the commencement of the project and review at each project stage gate to review the benefit case and value to consumers. A specific assessment of the risk associated with a project would take place considering the TRL level and the level of investment. Throughout the project lifecycle, our governance group would approve the next stage of the project or agree to stop or defer.

Section 7: Capabilities and Culture

Current Internal Capabilities

7.1 We have a dedicated innovation team that manages the strategy, funding, governance and regulatory reporting and compliance with the Good Practice Guide for IFI funded projects.

7.2 Whilst the central innovation team coordinates innovative activities, responsibility for sanctioning and prioritising these projects is shared with the Distribution Innovation Governance Group (DIGG) which is attended by representatives from all our directorates. This has served us well as the specialist knowledge, learning and output is retained within the responsible line management departments whilst the innovation team maintains accountability for the strategic alignment of outputs and goals.

7.3 An area we however do intend to focus on is the stakeholder feedback that our internal processes are unduly bureaucratic. We intend to review our procurement activities, such as the preferred supplier principles and the skill sets of our procurement colleagues, in order to improve the experience that our stakeholders have with our organisation.

Future Approach to Innovation

7.4 During the RIIO-GD1 period, we will build on our current approach to innovation. The innovation team will manage a portfolio of projects, yet each discrete project will be delivered by a dedicated expert project manager in the relevant business area.

7.5 We will make a step change in efforts to generate innovative ideas and will also develop a new capability, within our Future Distribution Networks team, to construct bids associated with the Network Innovation Competition (NIC).

7.6 We will ensure that we develop a culture of innovation in all of our activities. We will also ensure that we have a strong framework to ensure the value of our innovation programme is aligned to our business plan objectives, the benefits are tracked and monitored and risks mitigated.

Generating ideas and embedding an innovation culture

7.7 Innovation currently depends on a relatively small number of individuals spread through the organisation who bring forward new ideas or respond to external proposals. The appetite for innovation is growing but this needs to develop further. Our challenge is to grow that appetite for innovation through National Grid.

Field Force Engagement

7.8 Our field force will be encouraged to bring forward new ideas and new ways to improve our services. We will, therefore, look to improve engagement with our field force and provide the appropriate incentives and recognition for new ideas through a Field Force Engagement Programme and implementation of a joint Trade Union Working Group. This will deliver better means to communicate with and within the

Field including a new Tabloid style newspaper for our Field Force and a new Reward and Recognition Programme to recognise effort and reward success of innovative ideas to improve safety, customer and innovative ideas.

Chairman's Awards

7.9 The Chairman's Awards have been running for 6 years within National Grid. These awards were set up to recognise and celebrate outstanding contribution and achievements of employees who go above and beyond their day jobs, to deliver excellence and innovation for National Grid. Nominations for achievements cover a range of activities and initiatives that our employees look to improve. The main nomination categories are Safety, Environment, Health and Customer. During 2008 the Environmental Award Winner was Gas Distribution Keyhole Technology demonstrating how we took a US technology and improved our UK Operations. In 2009 the Customer Award Winner was Gas Distribution Trenchlink, an innovative road plating solution which improved road crossing connections, one man handling and enabled work to be completed in a smarter way thus minimising disruption in London.

7.10 Building on the Chairman's Awards, during the RIIO-GD1 period we will give greater prominence to innovation, encouraging this at every level of the company and communicating our successes and any associated best practice.

7.11 We will recognise our employees who come forward with initiatives, which change the way that we build, maintain and operate our system.

Delivery Principles

7.12 During RIIO-GD1, the overall innovation programme will be continuously reviewed to ensure it meets our company and business plan objectives and the delivery of our successful innovation projects will be given focus and priority to ensure benefits are realised. We intend to involve internal stakeholders earlier in the technology lifecycle process so delivery of innovation is seen as a 'pull' as opposed to a 'push' and embedded as best practice in our networks.

7.13 Initially, we intend to progress with delivering a balanced portfolio across the following benefit areas, although we will review this balance on an annual basis.

- NPV of Financial Benefit.
- Knowledge Transfer Benefit.
- Safety Benefit.
- Environmental Benefit.
- Network Performance Benefit.
- External Risk Benefit.
- Sustainable Development.
- Plus other Customer Benefits.

7.14 We will continue to monitor the benefits of innovation through the innovation lifecycle (stage gates) and at the point of delivery, using existing governance processes. The delivery benefit tracking will consider lessons learnt and whether the initially scoped benefit has been realised. The benefits will be further supported by a number of RIIO-GD1 output measures, which we have proposed within our main business plan.

Delivery Risk and Mitigation

7.15 Despite developing what we believe is a robust platform for driving forward our innovative activities; we have identified a number of risks associated with successful delivery of our Innovation Strategy. The risks are listed below with our proposed approach to minimise and/or mitigate those exogenous risks:

- Supply chain partner response to future energy challenges – we will make every effort to encourage suppliers into dialogue on future challenges, specifically seek to understand their views on energy challenges. We will ensure that the fully understand the supplier market and develop relationships with a wide range of suppliers, to encourage innovative solutions.
- Financial stability of suppliers to support the long term innovation programmes – We will ensure that our Supply Chain Management (SCM) approach is robust and continually review our supplier contracting arrangements and provide commercial support to suppliers.
- Network Innovation Competition (NIC) bidding commitment – we will work closely with our preferred external suppliers to minimise the risk of developing an unsuccessful NIC bid. We will also focus on a limited number of priority bids.
- Multiple collaboration partners leading to delays in delivering projects – we will ensure that the collaboration contracts are clear in their scope and timescales for delivery.
- Slow to respond to the need to change – we will respond to stakeholder feedback and review our internal governance processes to minimise delays in delivering innovative projects.
- Failure to share learning and best practice – we will establish best practice forum and fully utilise our best practice engineers to ensure the benefits of innovation are realised.

Section 8: External Collaboration

Raising Awareness

8.1 In an effort to improve collaborative opportunities, we will continue to raise awareness of the innovation incentives with our stakeholders, both internally and externally, and will maintain relationships with research bodies. We will continue to regularly present our innovation objectives to the SBGI and core R&D suppliers and specifically will ensure that Innovation features on the agenda.

8.2 During GDPCR1, we were able to agree a broad set of conditions, legal and collaborative arrangements to better work with other GDN's and a joint gas innovation strategy. This is an area for improvements during RIIO-GD1 and we will consider the potential establishment of a GDN collaboration forum / platform in line with our stakeholder feedback.

External Collaboration

8.3 We believe that a process of external collaboration is essential to the delivery of a successful programme of innovation. On that basis we intend to:

- Building on Stakeholder feedback, we are committed to improve our engagement with suppliers to make it easier to work with us by raising awareness, establishing forums and exploring new ways to effectively filter new ideas by collaborating with other organisations.
- Talk to manufacturers and suppliers to ensure industry investment in new products is aligned with our short, longer term and strategic needs.
- Work with our R&D suppliers, government agents, other utilities and universities to make efficient use of funding, to maximise innovation opportunities and, where appropriate, to share operational knowledge.
- Seek to influence governments and regulatory bodies on the forward energy agenda incorporating knowledge gained through innovation.
- Collaborate with other GDNs, Gas Transmission, network operators and other utilities, to maximise opportunities and share operational knowledge for the benefit of the energy industry and UK plc.
- We will also increase the visibility of our innovative activities via a web-based innovation portal. This portal would not only provide transparency for our innovation activities but would also provide a forum by which potential collaborators could approach us.

8.4 More specifically, we have established and will maintain relationships with the following organisations in order to ensure we remain at the forefront of Innovation during the RIIO-GD1 price control period. Membership and involvement in these groups enables not only the opportunity to generate more innovative ideas with a wider group, but allows for the sharing of knowledge and information to the benefit of the wider energy industry.

8.5 European Pipeline Research Group (EPRG)

- EPRG is a cooperation of European pipe manufacturers and gas companies who undertake research directed to increase the integrity and safety of high pressure networks. There are currently 20 projects National Grid are collaborating in with a 15:1 leverage ratio with the main benefits being shared knowledge on best practice and incidents.

8.6 Pipeline Research Council International (PRCI)

- The main focus for National Grid is the assessment, preventions and migration of integrity threats such as mechanical damage and external corrosion. Leverage is dependant on number of participants within each project.

8.7 European Gas Research Group (GERG)

- GERG is a cooperation of European gas distribution companies who undertake research and development to increase the integrity and safety of gas distribution systems. National Grid participates in the Distribution stream of GERG and leverage funds by collaborating on projects relevant to their network. Leverage in 2010 was 4:1 ratio.

8.8 Pipeline Industry Research Club (PIRC)

- PIRC main role is the assessment, prevention and investigation of PE threats and opportunities via collaborative research which include butt fusion welding and non destructive testing of joints. This Club maintains the integrity of PE pipelines.

8.9 Future Collaboration Forums

- Energy Network Association (ENA) acts as a strategic focus and channel of communication for the industry and provides a forum of discussion among company members. As a member of the ENA R&D Working Group, we work directly with the gas distribution network companies on relevant projects. In addition we work closely with other utilities on a variety of joint funded collaborative projects and forums.

Developing the Right Collaborative 'Mix'

8.10 The following sets out our 'desired state' in respect of the collaborative relationships we want to develop with our external organisations:

Figure 8.1 - 'Desired state' collaboration with external organisations

Research Organisations	▪ Company wide relationships with leading organisations (and company wide contracts where financially attractive) ▪ Collaborative working to maximise leverage where commercial interests are not threatened, with specific research where justified ▪ More active role for key research areas, such as seats on committees, to enable us to have greater influence on scope and priorities of projects that of most importance to us
Technology Suppliers	▪ Greater influence on where key suppliers invest their R&D budgets, focussed where suppliers see our view as important ▪ More informed buyer to improve engagement and influences with suppliers ▪ Encourage suppliers to invest in priority areas
Consultants / Advisors	▪ Technically focused input from research organisations supplemented by broader business-based advice ▪ Relationships with advisors that can provide an independent view on implications of technological or commercial products
Other Utilities and Network Operators	▪ Work together to consider and manage proposals for collaborative Innovation projects ▪ Development of specialist project groups to oversee and manage projects that have passed the appropriate success criteria ▪ Share and promote good practice and monitor R&D developments

Annex 1: Awards and Achievements

Introduction

a1.1 We have a good track record for driving industry innovation and have started to build a more innovative culture in preparation for addressing the challenges we face in RIIO-GD1. We believe that this strong focus and commitment to be at the forefront of Innovation can be further demonstrated by the number of external awards and recognition we have received over the past few years.

IGEM Innovation Awards

a1.2 In May 2011, our Beam Drilling Technology won the IGEM SBGI Innovation Award. The Beam Drilling system challenged 30 years of custom and practice by pushing the drilling base onto a main to affect a seal, significantly reducing excavation and public disruption – this innovation saved 220 man days between August 2010 and May 2011.

a1.3 In May 2010, the Pipehandler was submitted for an IGEM Innovation Award in conjunction with the supplier Steve Vick for the innovative technology and technique for inserting PE pipes into old gas mains, avoiding operators having to handle the PE pipe or enter the trench significantly reduces the risk of injury.

Discretionary Reward Scheme (DRS)

a1.4 We have also been consistently rewarded under the Discretionary Reward Scheme, which was introduced as a part of the Gas Distribution Price Control Review for the period 2008 – 2013. Specifically in 2010-11, we were awarded a total of £1 million for the following innovative initiatives:

- Network Extensions: we found and successfully implemented a low carbon 'heat' solution for delivering network extensions to multi-occupancy dwellings and further improved our network extensions application process - the fastest and the only paperless application process in the sector.
- Environment: we have become the first GDN to connect a purpose-designed Anaerobic Digestion plant to the gas grid and have introduced a sector-leading and innovative meter recycling facility.
- Safety: we have been innovative in our communications through the use of social media where using Twitter and Facebook is described by customers as *"fantastic"* and *"very helpful"* when it comes to updating them during emergency incidents.

a1.5 We were also awarded £500,000 in 2009-10 and £350,000 in 2008-09 under the Discretionary Award Scheme for similar innovative initiatives.

Annex 2: Keyhole Technology

Background

a2.1 During a knowledge exchange programme, with Keyspan USA in October 2006, 'Keyhole Technology' was identified as a process with the potential to improve UK Operations. It was envisaged that the technique could support the 'Road to Zero' waste strategy, reduce National Grid's carbon footprint, improve safety and increase productivity.

a2.2 In November 2006, two USA Keyhole trucks were shipped to the UK to facilitate a UK/USA field evaluation programme. An Operational team from the USA attended to train UK teams and share knowledge of the operation.

Figure a2.1 - Pictures illustrating the use of Keyhole trucks

a2.3 As a result of this exchange, a product development programme was undertaken that saw the design, build and introduction of the first Keyhole Technology Vehicles specifically designed for UK Gas Operations. These vehicles, introduced into London Network in October 2007, enabled a further evaluation of the process. The evaluation period identified further significant benefits which have led to Operations placing an order for 5 additional keyhole sets with delivery commencing June 2008. By September 2008, each area within National Grid Gas UK will have a keyhole unit.

a2.4 Fundamental to the success of this programme has been the ability and willingness of UK and USA staff to share information and exchange best practice ideas. Working as a virtual team, an ever-increasing expansion of the tooling, to enable environmental and safety benefits to be maximised, has and is taking place.

Figure a2.2 - Keyhole Technology Vehicles

Benefits

We are capturing not only includes the cost, productivity and safety benefits but also the key environmental aspects. The most significant and wide reaching environmental benefit is the onsite reuse of excavated materials. This capability has appreciably minimised the impact our works have on the environment and public whilst maintaining the highest standards of safety and performance.

a2.5 Excavation completed using traditional methods requires the use of mechanical powered excavation machinery, vehicles to remove excavated materials from site to landfill, quarry machines to prepare virgin materials, vehicles to import these materials to the excavation site and specialist vehicles to complete the reinstatement of the highway surface.

a2.6 Each and every one of these stages of the traditional process adds to the company carbon footprint and uses up valuable natural resources. Furthermore, disposal of excavated material places burden on our already overflowing land fill sites.

The Process

a2.7 Keyhole technology works by drilling an 18 or 24 inch hole through the road surface. Excavation is carried out by vacuum to enable access to the gas main. The repair is then carried out using long reach tools. Once the work is complete the original excavated material and road surface are reused to reinstate the hole.

Figure a2.3 - Illustration of Keyhole technology repair process

a2.8 The ability to reuse the on site excavated materials and replace the original road surface has been shown to reduce operational time from up to 7 days to as little as 5 hours which facilitates many environmental benefits.

a2.9 On-site reuse of materials removes the need to use additional vehicles and resources to restore traffic flows. The Keyhole process has all materials on site ready for instant use. By quickly and efficiently restoring traffic flows reduces traffic congestion which in turn reduces the carbon emissions from public vehicles affected by our works. There are also added benefits of lower noise pollution and the vacuum excavation technique avoids harmful damage to tree roots.

a2.10 Research has shown that there is the very real potential to utilise Keyhole technology to replace and install new services, to abandon services, install repair clamps and many more street works activities. These tooling developments will enable further benefits to enhance National Grid's environmental and safety performance.

Summary

a2.11 Keyhole technology delivers the following benefits;

- Significant reduction in CO2 equivalent emissions from our repair activity.
- Significant reduction in the use of 'virgin' reinstatement materials.
- Significant reduction in amount of material sent to land fill.
- Significant reduction in the number of vehicles and processes involved with excavation / repair / reinstatement activities.
- Significant reduction in time taken to complete repair works and thus reduced congestion.
- Reduces time for repairs to be completed and thus a reduction in the emissions of methane into the atmosphere.
- Elimination of road breakers and overall job duration reducing the nuisance of noise.
- Vacuum excavation is not harmful to tree root systems.
- Removes the need for the operative to enter the excavation thus improving the working environment.

Conclusion

a2.12 It has already been quantified that Keyhole excavations are 80% smaller than traditional excavations which significantly reduces reliance and use of valuable natural resources, significantly and positively contributing to our environmental performance in a number of areas.

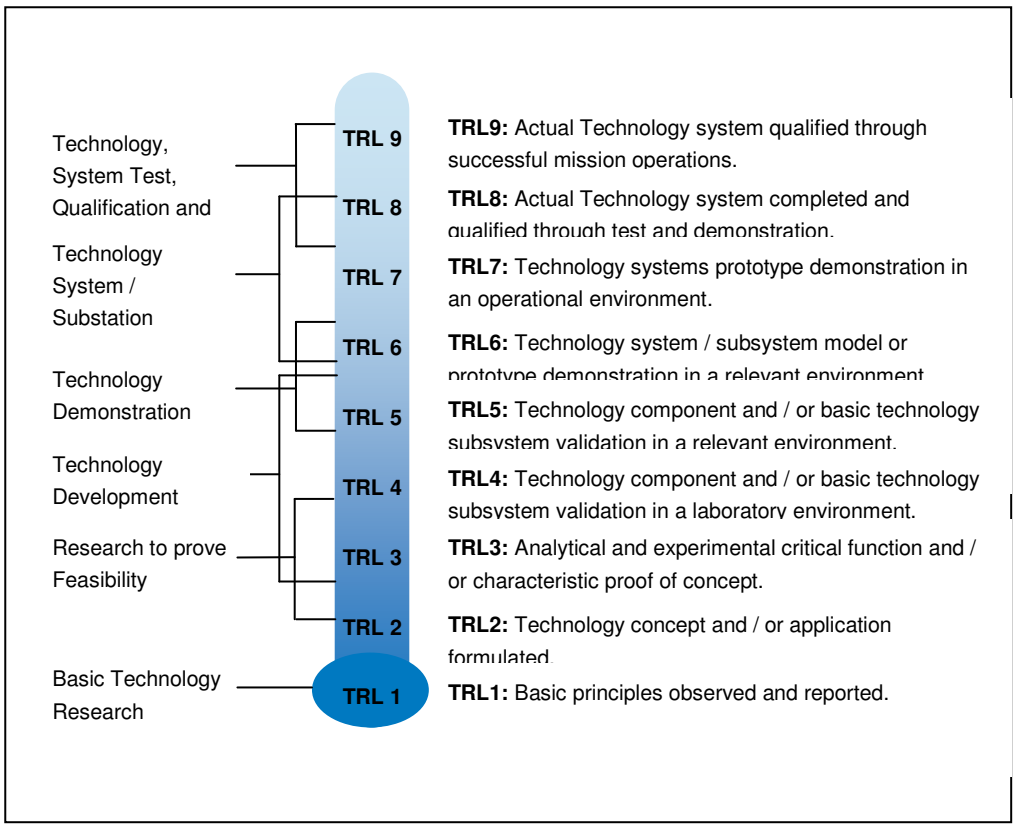
a2.13 Highways Authorities are actively welcoming the implementation of what is described as the greatest leap forward in street works since the introduction of mechanical excavators. Other utilities are increasingly interested in our successful introduction of the technology thus enhancing National Grid's reputation as a leader in technology.

Annex 3: Technology Readiness Levels

Background

a3.1 Technology Readiness Level (TRL) is a measure used by many of the world's major companies to assess the maturity of evolving technologies (materials, components, devices, etc.) prior to adopting or incorporating that technology into a system.

Figure a3.1 - Technology Readiness Levels (TRL)



The Innovation Project Lifecycle

a3.2 The Technology Readiness Level (TRL) indicates how close a technology is to becoming both technically and commercially viable and can be seen above. Level 1 relates to basic research with no obvious purpose more commonly known as 'Blue Sky Research' and Level 9 on the TRL scale indicates products/information readily available with no development required.

a3.3 Currently Gas Distribution innovation activities have been focussed between TRL's 2 and 8. This range ensures that Gas Distribution balances both tactical and strategic projects within its portfolio but also ensures that the innovation money is being used for innovation activities and not purchasing existing solutions.

a3.4 To establish a project's importance can depend on a number of factors, technological advancement, size, cost, benefits, risk (both technical and commercial), leverage, strategic or tactical positioning, and whether it is short or medium term in nature.

Annex 4: Beam Drilling Technology

Background

a4.1 Drilling and tapping a gas main is fundamental to many activities carried out by National Grid Gas Operations. The activity and process is well embedded into the industry and is completed on a daily basis using tried and trusted equipment.

a4.2 As part of National Grid's Innovation Funded Initiative program time and resources are being invested to develop ways of inspecting, maintaining and expanding the gas network through non intrusive or reduced excavation techniques.

a4.3 One such development has seen collaboration between National Grid, ALH Ltd and GL Noble Denton Ltd, that challenges 30 years of custom and practice in the manner in which a drilling valve is secured to a gas main.

a4.4 Traditionally to drill a gas main to enable a service connection, internal camera inspection, internal joint location or to internally treat joints, a suitable size drilling is required to allow the relevant equipment to be inserted.

a4.5 For the last 30 years this drilling has been achieved using any one of a number of proprietary drilling valves all of which have one common factor. To secure the drilling machine to the main it is necessary to feed chains under the main to pull the drilling valve down to create a seal.

Figure a4.1 - Beam Drilling System

Typical excavation required to drill tap and install pressure & bypass points on 48" Main. Excavation required enabling a chain to be passed under the main to secure the drilling base

a4.6 To feed the chain under a main operatives are required to carry out full circumferential excavation of sufficient size to enable safe entry into the hole to complete the task. The size of the excavation needed to allow safe entry is proportional to the size of the main hence larger mains require larger excavations which introduces:

- Environmental implications created through the excavation and reinstatement.
- Public disruption caused by the duration of the works.

a4.7 The Beam Drilling System developed as part of an Innovation Funded Initiative project offers an opportunity to remove the need to dig large holes in order to secure a drilling base to a metallic main. Rather than passing a chain under the main the novel design pushes the drilling base onto the main.

a4.8 A small excavation is carried out to expose the crown of the main; this can be through small slit type trenches or by employing the use of Core and Vacuum technology. Two beams are placed over the opening and two weight packs are positioned, one on either side of the excavation. Four adjustable Jackstays are attached between the beams and the drilling base. The seal is established between the drilling base and the main applying pre - determined torque load to the 4 jackstays thus creating a gas tight seal following which work can commence.

a4.9 The system has been developed with the operative in mind. The ALH Ltd System One kit has been used in the industry for many years and operational instructions are already embedded into company operating procedures. By utilising familiar technology the subtle changes the operative is required to adopt in order to complete the activity using the Beam Drilling System are minimal and implementation issues subsequently reduced. It has been found that an operative who is shown the operation of the kit an average 3 times becomes more than competent in its safe use minimising implementation effort.

Figure a4.2 - Beam Drilling System

Typical excavation required to drill tap and install pressure & bypass points on 48” Main Using the Beam Drilling System

a4.10 Operator and system safety has been a key factor within the development with the design of the kit and its operating procedures focusing on human factors. Rather than ‘reinventing the wheel’ it has been possible to adapt launch heads for internal cameras, internal joint locators and internal sealing equipment to work from the surface. Site layouts, excavation sizes and delivery locations have been identified to minimise manual handling and slips trips and falls.

a4.11 The weights have been designed for delivery in two 1 ton packs, each pack consisting of 20 weights each weighing 50kg. The design of the weights and the carrying handles has been completed in such a way as to require 2 operatives to move them thus reducing the risk of personal injury. The positioning of the beams and weights has been proven to reduce human fatigue and reduce the risk of injury when compared to the weight and manual handling that would have been encountered if using traditional trench support.

a4.12 Fundamental to the process is the removal of the operative from the excavation in order to carry out the activity. All operations are conducted with the operative

standing on the road surface and using specially designed long handled tooling to carry out the task down the hole. This process removes the risks and controls necessary to ensure operative safety normally faced by an employee working in deep excavations or confined spaces.

a4.13 The introduction of The Beam Drilling system and the design of specialist tooling now enables an operative to safely complete a number of activities without entering the excavation such as:

- Cameras insertions.
- Joint and tapping location.
- Water extraction.
- Joint sealing.
- Service connections.
- Installation of pressure monitoring points.

a4.14 The Beam Drilling System has operating capabilities of;

- Mains of diameter 4" – 48".
- Max operating pressure of 2bar.
- Operating depths of 300mm – 2000mm.
- Average operating area being 600mm – 1500mm.

a4.15 The reduced excavation enables the activity to be completed in a shorter timeframe. The small excavations also open the possibility to utilising road plating systems to minimise impacts. The reduction in excavation has hidden benefits:

- Significant reduction in CO2 emissions from our works.
- Significant reduction in the use of 'virgin' reinstatement materials
  - Some 450 tonnes since introduction in August 2010.
- Significant reduction in amount of material returned for land fill
  - Some 450 tonnes since introduction in August 2010.
- Significant reduction in the number of vehicles and processes involved with excavation / activity / reinstatement process
- Significant reduction in time taken to complete works and thus reduced congestion.
  - A reduction of some 220 days since introduction on August 2010

- Speed of process results reduction in time for activity being carried out thus a reduction in the emissions of methane into the atmosphere.
- Elimination of road breakers and overall job direction reduces noise.
- Reduced risk of damage to third party plant due to smaller excavations.
- Removes the need for the operative to enter the excavation thus improving the working environment.
- Returning of highways to full operation quicker.

a4.16 Currently the system is limited to use on gas mains however due to the nature of the equipment and the tooling technology transfer to other utilities requiring internal inspection from reduced excavations is more than feasible.

a4.17 The Beam Drilling System meets and challenges traditional technologies. By changing the way in which the drilling valve is secured to the main National Grid will be able to reduce the impact its works have on the Environment, Third parties and members of the public.

Annex 5: Pipe Handler Technology

Extract from IGEM and SBGI Nomination Form for the 2010 Gas Industry Awards

Reason for Nomination

a5.1 'Pipe Handler': Innovative technology and technique for inserting PE pipes into old gas mains, avoiding operators having to handle the PE pipe or enter the trench significantly reduces the risk of injury.

Achievements / Criteria for Assessment

a5.2 Currently stand alone PE pipe pushing machines are used to insert larger sizes of PE pipe into metallic mains that are being replaced. These machines need to be anchored to the ground surface or anchored within the trench which can cause issues at times. Also the pushing machine requires a separate power pack to drive it.

a5.3 By contrast the Pipe Handler attaches to the quick hitch or bucket pins of an excavator. It is designed to grip the PE, position it in the excavation by means of a swivel head and then insert it into the host pipe. The entire operation is controlled from the cab avoiding the need for operators to enter the trench. The Pipe Handler works by grasping the PE pipe in its jaws, gripping it and pushing it forward using the hydraulic power of the excavator. The model handles pipe diameters up to 355mm for use with a typical hydraulic excavator. Shell inserts are available to reduce the diameter of the gripping jaws to fit specific pipe sizes.

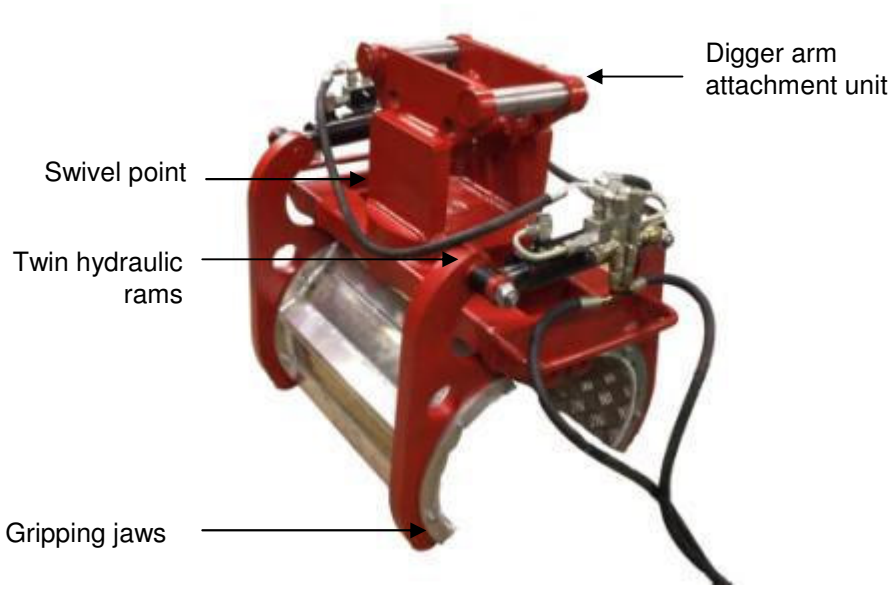
a5.4 Insertion speeds of 10m per minute are typical and long lengths of pipe can be inserted in one operation. Hence a major safety benefit is that fewer excavations in roads and footpaths need to be left open for long periods, minimising the hazards for road users and pedestrians.

a5.5 Pipe Handlers are currently in use during extensive field trials in the four the National Grid Gas Alliances and within Operations Coalitions. This has been possible through the use of the Gas Distribution Innovation Funding Incentive.

Case Study

a5.6 In Sheffield the Pipe Handler was used to insert a new 315mm PE pipe into an existing 18"/20" low pressure cast iron main. The project, involving 1000 metres on either side of the road, was completed in record time. With over 100 businesses being supplied by the gas main it was crucial for the replacement operation to be carried out with minimal disruption in gas supply, as well as maintaining access into the establishments. Only a single excavation was required on each side of the road for the Pipe Handler to insert the 315mm pipe.

Figure a5.1 - The Pipe Handler



Annex 6: Projected Utilisation of NIA

Figure a6.1 - Projected Utilisation of NIA

	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21
1. Efficient and Safe Work Delivery and Removal of Risk	£2.5m	£3m	£3.5m	£4m	£4.5m	£4.5m	£4.5m	£4.5m
2. Asset Condition and Network Optimisation	£2.5m	£3m	£3.5m	£4m	£4.5m	£3.5m	£3.5m	£4.5m
3. Transition to Low Carbon Economy & Minimise Environmental Impact	£1m	£1.5m	£2m	£2m	£3m	£4m	£4m	£3m
4. Customer and Stakeholder Satisfaction	£1m	£1m	£1m	£1m	£1.5m	£1.5m	£1.5m	£1.5m
5. Enhanced Industry Frameworks and Commercial Services	£0.5m	£0.5m	£0.5m	£1m	£1.5m	£1.5m	£1.5m	£1.5m
Projected utilisation of NIA:	**£7.5m**	**£9m**	**£10.5m**	**£12m**	**£15m**	**£15m**	**£15m**	**£15m**

NOTES

1. In years 2013/14 and 2014/15 we assume a £500k IFI roll over project spend within the Asset Condition and Network Optimisation theme
2. We have assumed 10% of spend is utilised for NIC bid, which is included in the Transition to Low Carbon theme in first 2 years
3. Asset Condition and Network Optimisation and Efficient and Safe Work Delivery and Removal of Risk will remain constant and our highest priority throughout the RIIO-GD1 period
4. The Transition to Low Carbon Economy & Minimise Environmental Impact theme steadily increases to meet 2020 target and support NIC bids
5. Customer benefits are also demonstrated within all of the first three themes, and is a constant spend that is aimed at improving our customer experiences
6. Enhanced Industry Frameworks and Commercial Services innovation will need a culture change and knowledge rather than large project spend to move forward so lighter spend to reflect this