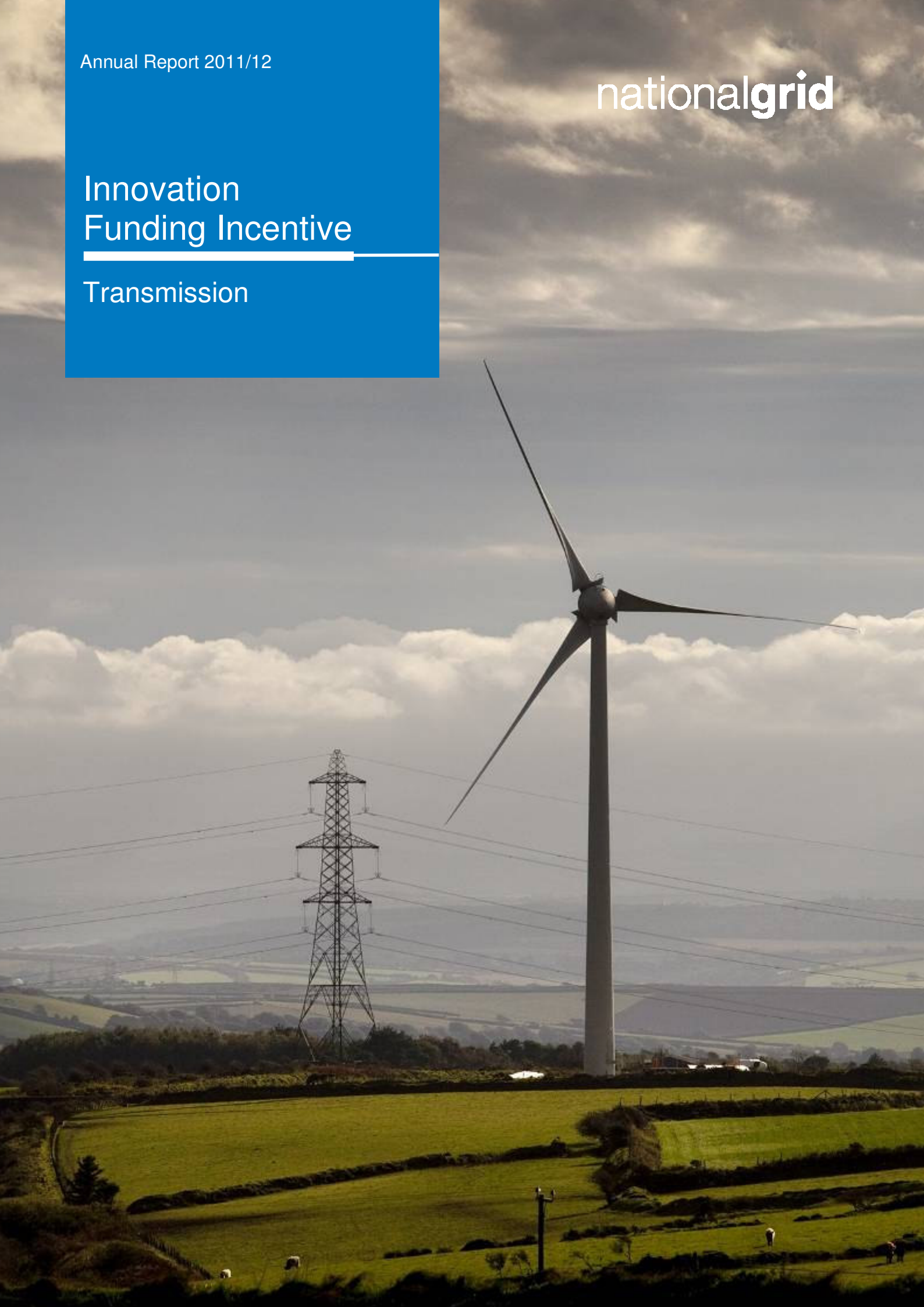
Annual Report 2011/12

nationalgrid

Innovation Funding Incentive

Transmission



Contents

About National Grid Transmission

National Grid
National Grid owns and operates the high voltage electricity transmission system in England and Wales and operates the Scottish high voltage system. National Grid also owns and operates the Gas Transmission system throughout Great Britain. Through its low pressure Gas Distribution business, National Grid distributes gas to approximately eleven million businesses, schools and homes.

> “National Grid maintains an operational reliability of 99.99998%”

Electricity Transmission
National Grid owns and maintains the high voltage electricity transmission system in England and Wales, together with operating the system across Great Britain, balancing supply with demand on a minute by minute basis. There are over 9,000 circuit miles and 337 substations at around 240 sites.

Gas Transmission
National Grid owns, maintains and operates the national gas transmission system in Scotland, England and Wales, balancing the flow of high pressure natural gas between import terminals and the regional gas distribution networks, gas storage facilities, international interconnectors, power stations and other large industrial customers.

> “The NTS consists of 4,300 miles of high pressure pipeline”

Introduction from Nick Winser

Welcome to this report covering the fifth year (2011/12) of National Grid's Transmission Innovation Funding Incentive (IFI) research and development program.

2011/12 has again seen a number of new developments emerge as we really test ourselves to create new solutions that meet the needs of our customers and stakeholders. This supports our vision which remains consistent; we aspire to being the foremost international electricity and gas company now, and are committed to be an innovative leader into the future.

The IFI program is key to supporting this as we invest in research and development with our partners, suppliers and educational establishments. Over the past year we have engaged a wide range of suppliers on all asset areas with significant innovation including;

- The development of HVDC technology and knowledge
- Overhead line maintenance, in particular liveline via helicopter or robotics
- Improved substation maintenance tools
- Geomagnetic induced current monitoring
- Coatings for both gas and electricity assets
- T pylon and composite cross arm development
- Gas asset integrity management
- External contamination detection and measurement

These initiatives have delivered considerable value now, and will continue to do so as these new technologies are installed on our networks.

Looking forward to RIIO, Innovation is at the heart of the new regulatory framework. It is vital that the industry as a whole embraces the innovation challenge of the next decade, using technical and commercial innovation to deliver efficient investment in the RIIO-T1 period. Ofgem's Project Discovery identified that £200bn of investment would be required in Britain's energy infrastructure this decade to deliver secure and sustainable energy supplies. This investment will help facilitate the UK's drive towards a low carbon economy, as well as supporting the achievement of meeting the 2020 climate change targets.

The need to increase the amount of innovation has never been more acute. Over the next decade, we forecast substantial investment in our networks. In Gas Transmission we need to harness innovation to fulfil our statutory environmental obligations, operate a more flexible network and facilitate the connection to the NTS for our customers. This will support the flexible operation of gas fired generation plant that will provide the necessary reserve for wind generation as the electricity sector decarbonises. In Electricity Transmission we need to harness innovation to upgrade our transmission assets and operate a more flexible network. We need to connect new sources of lower carbon generation as well as looking for ways to reduce the direct environmental impact of our own network.

With anticipated workload growth, it is vital that we minimise cost increases and become more efficient at what we do. We will continue to drive innovation in our business and support the development of new technology solutions to build the networks of the future.

Nick Winser,
Director National Grid UK

Investment in Innovation

With the challenges of the next decade, we welcome the proposed regulatory changes for incentivising innovation. This will allow us to continue to deliver innovative solutions such as the key innovation achievements that we have progressed in the current price control period.

These include

- **Risk and Criticality**
  Development of Network Output Measurements (NOMs) that have given rise to an estimated £1bn reduction in the required capex spend in the RIIO-T1 period

- **Western HVDC Link**
  Once developed, it will be the first 600kV subsea cable in the world, at 420km in length, helping minimise transportation losses and constraint costs

- **T-Pylon Design**
  This will potentially allow us to reduce pylon heights from around 55 metres to circa 35 metres, helping reduce the visual impact of our assets

- **Connect and Manage**
  Enabling earlier connection of approximately 13 gigawatts (GWs) of generation, by an average of five years

- **SMARTer Network Operation**
  Increasing boundary capacity through deploying solutions such as circuit rating enhancements, operational tripping schemes and greater condition monitoring

- **Variable Speed Drive Air Compressors**
  Air compressors provide a supply of compressed air to pneumatic valve actuators and nitrogen charging for dry gas seals on gas compressor units. This innovation will reduce our electricity usage at individual sites (therefore reducing our carbon footprint) and our subsequent operational costs.

- **Above Ground Meter Enhancement**
  A successful pilot of a new flow computer with upgraded software has helped provide more accurate flow meter data and customer billing.

- **Two Stage Recompression**
  This technique reduces the volume of methane gas released to atmosphere when carrying out maintenance on or decommissioning a pipeline.

> *"Through its R&D Framework Agreements with key Universities, National Grid has ensured the retention of a strong, relevant UK research base and has demonstrated its commitment to supporting longer-term research in pursuit of strategic national objectives. Over the next decade, the need for R&D will continue to increase and UK-based research groups have the capacity to meet this requirement. A commensurate increase in the level of Network Innovation Allowance therefore seems entirely in keeping with the goal of establishing a firm foundation for the development, demonstration and deployment of new technologies to support the anticipated radical alterations in the use of the electricity transmission network."*
>
> Professor S.McArthur,
> Strathclyde University

Transition to RIIO

Our Innovation Portfolio delivers a wide variety of benefits across the business in a broad range of areas. Over the RIIO period we expect to increase on the benefits delivered by the current IFI scheme and the wider innovation highlighted on the previous page, while expanding our Innovation Portfolio to deliver Innovation in new areas.

> *"Innovation would die-off without specific funding."*
>
> Stakeholder comment, stage two workshop, 5th April 2011

National Grid has strived to maintain a balanced portfolio over IFI and will be looking to maintain a focused but balanced portfolio going forward into RIIO, recognising that the broader scope of Network Innovation Allowance (NIA) incentivises greater innovation across the organisation. To ensure the benefits of the current innovation are carried through to the business, National Grid will be seeking to carry forward some projects currently ongoing under IFI.

National Grid has a strong focus on safety, protecting the public, our staff and contractors. This is reflected in our current innovation portfolio. In 2011/12 we spent £1.3m on gas and electricity safety related projects. The benefits of these projects range from ensuring asset life can be extended safely, to developing working practices with innovative equipment. This can be utilised in order to reduce the manual handling issues associated with some maintenance procedures. Manual handling issues are a key innovation area for National Grid.

Our Innovation portfolio contributes to informing the investment decisions surrounding the network expansion, reinforcement and replacement plan. Projects such as "Optimising the operation of an integrated DC link within an AC system" research the requirements of transmission technology which will be essential for transmitting power from low carbon generation efficiently. This research maximises the value and capacity of existing assets reducing the requirements for system reinforcement. Given the scale of reinforcement facing the UK this is a key area where we expect the innovation portfolio to increase. Projects which contribute to Optimising Asset Management, developing our asset management strategies minimising costs and reducing network risk, accounted for £1.83m of spend across Gas and Electricity this year.

National Grid is entering a more challenging operational environment. Over the last couple of years we have been developing and operating a network with increasing amounts of intermittent and inflexible generation which has necessitated £1.12m in System Operability research. This research seeks to ensure that transmission assets are utilised efficiently, safely and reliably. Given the increasing volatility of energy flows and usage over the coming decade we expect to see demand for research in this area expand. This work is critical to ensure we can operate and maintain our networks as we connect new sources of generation, helping to facilitate the decarbonisation of the energy sector.

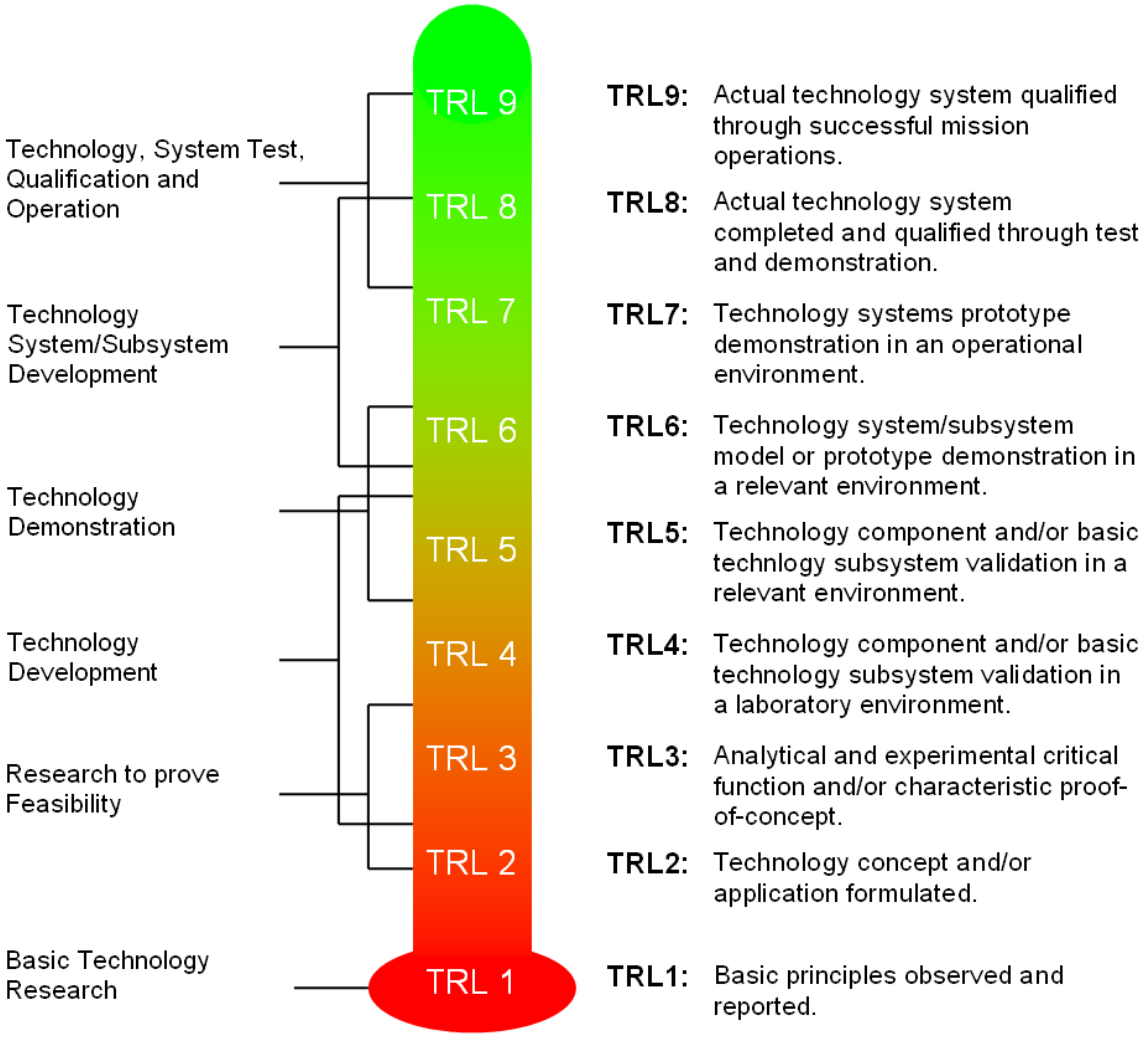
We continue to look at ways of reducing our own CO_2 (equivalent) emissions, as well as utilising new technologies and practices to contribute towards the sustainability of the products and tools we use. Our research into "Alternatives to venting natural gas" and "Management of SF_6" contribute directly to reducing our emissions and assist the UK in hitting its carbon reduction targets.

Going forward into RIIO, we expect to improve our understanding of customer behaviour and the impacts of new commercial arrangements. We will embrace innovative solutions to share information with our stakeholders and inform the consumer. Presently our research into charging frameworks, charging volatility and information provision accounts for £153k of spend across the IFI Portfolio. The broader scope of the NIA will allow us to increase the volume of research in this area, allowing us to narrow the uncertainty surrounding the new Electricity Market arrangements.

Technology Readiness Level

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

Technology Readiness Level is a key part of understanding the risk associated with a project. National Grid creates a balanced portfolio of projects ranging from TRL level 2 – 8, This range ensures that National Grid balances both tactical and strategic projects within its portfolio but also ensures that innovation funding is used for innovation activities and not purchasing existing solutions, where possible National Grid seeks to minimise the risk associated with lower level TRL projects by entering into collaborative agreements, utilising funding from additional sources. This balanced approach is representative of the broad range of challenges National Grid faces as well as the innovative solutions and projects that currently make up our innovation portfolio.



With the introduction of the Network Innovation Competition (NIC) in next years regulatory framework, National Grid is aiming to take forward innovative technologies though to full scale demonstration projects focussed on delivering value to National Grids customers and assisting the transition to a low carbon economy.

The projects highlighted in the following pages all include an indication of their Technology Readiness level. The highlighted reports are generally towards the end of the TRL scale (e.g. TRL8 & TRL9) as they are more developed towards a final solution.

Innovation Profile

The way we look at our Innovation portfolio is changing. Rather than focussing on the innovation of specific asset types, we are now profiling our portfolio based on key themes. These themes have been developed with our stakeholders and other businesses within the energy value chain to deliver excellent levels of safety, reliability, security, customer service and environmental performance. By focusing on these themes we can connect our innovation portfolio directly to our RIIO commitments to deliver safe, efficient and reliable energy networks to the consumer.

The following pages display our Innovation Portfolio, broken down into each key theme. Each segment is then further broken down into its constituent sub-themes. This allows us to see in some detail how the Innovation funding is being allocated to meet our objectives.

Of the themes, we spent the largest proportion of the Electricity Transmission budget on Reliability. These projects focus on the way we acquire data about our assets, improving maintenance techniques to reduce maintenance times and increasing the life span of assets to recover maximum value from each asset.

"System Operability" projects accounted for a sizeable proportion of the electricity spend. These enable innovative new transmission assets such as HVDC links, series compensation and Quadrature Boosters to be efficiently utilised.

The largest proportion of our Gas spend was on Environmental projects. These projects focus on the development and trial of innovative solutions to reduce volumes of gas vented during operational procedures. These projects then contribute to reducing our CO_2 (equivalent) emissions.

The profile also shows us how we can expand our innovation spending moving forward into RIIO. Currently Customer Satisfaction and Commercial innovation accounts for only 1.4% of our innovation spend. This is because the IFI scheme has an asset focus, and there are relatively few potential projects with an overlap between areas such as commercial innovation and asset based research and development. There are also sub-themes that we have outlined in RIIO where we have little or no spend at present. These include Ancillary Services, Information Provision and Information Security. We expect, under RIIO, these areas to expand as we fund broader innovation across National Grid.

> *"We cannot under-estimate the scale of the engineering challenge that will be needed to deliver a sustainable energy future. One which I believe is going to lead to a renaissance in engineering. As we embark on this transformation, we are going to need new technologies, new players, and new engineering talent."*
>
> Steve Holiday CEO National Grid

Electricity Profile

Connections £1.02m

We are developing techniques to maximise System Access. This means reducing constraints due to maintenance and increasing the speed and flexibility of our maintenance schemes. By creating a Smarter Transmission Philosophy we can ensure our networks are capable of connecting large volumes of renewable generation and active distribution networks. And building on the success of connect and manage, we are developing methods to manage the system in more efficient ways, thus Facilitating Connections of new generation.

System Access £517k

Smarter Transmission Philosophy £443k

Facilitating Connections £59k

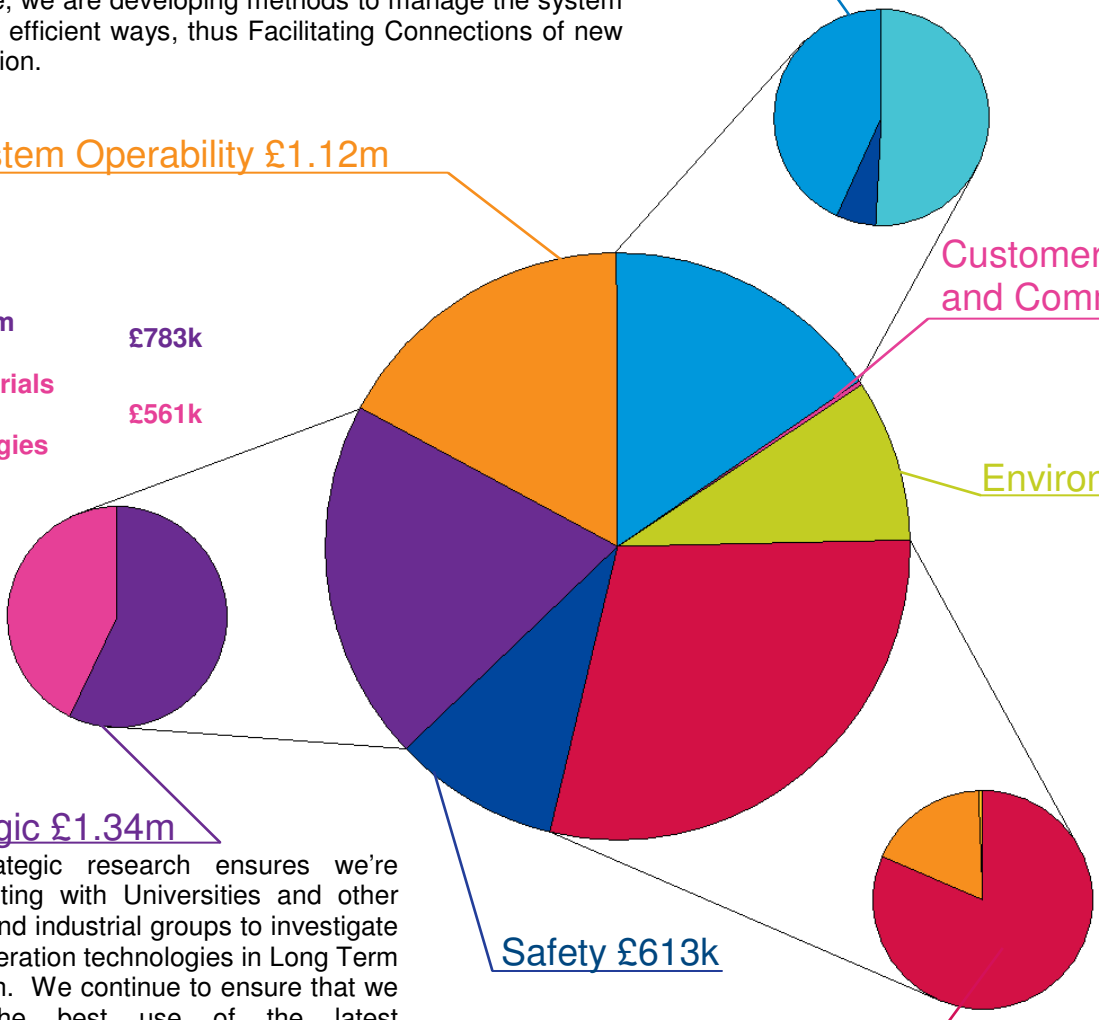
System Operability £1.12m

Customer Satisfaction and Commercial £19k

Long Term Research £783k

New Materials and Technologies £561k

Environment £568k



Strategic £1.34m

Our strategic research ensures we're collaborating with Universities and other utilities and industrial groups to investigate next generation technologies in Long Term Research. We continue to ensure that we make the best use of the latest technologies and develop New Materials.

Safety £613k

Reliability £1.89m

We are Optimising Asset Management by reducing maintenance times, minimising the need for human intervention, optimising asset life and creating a step change in real-time data on Asset Performance. We are developing new tools for Knowledge Retention and training while addressing the issue of Information Security. We continue to innovate in our Network Protection and Control systems to cope with operating an increasingly complex transmission network.

Optimising Asset Management £1.54m

Network Protection and Control £341k

Information Security and Knowledge £12k

Gas Profile

Customer Satisfaction and Commercial £134k

Strategic £569k

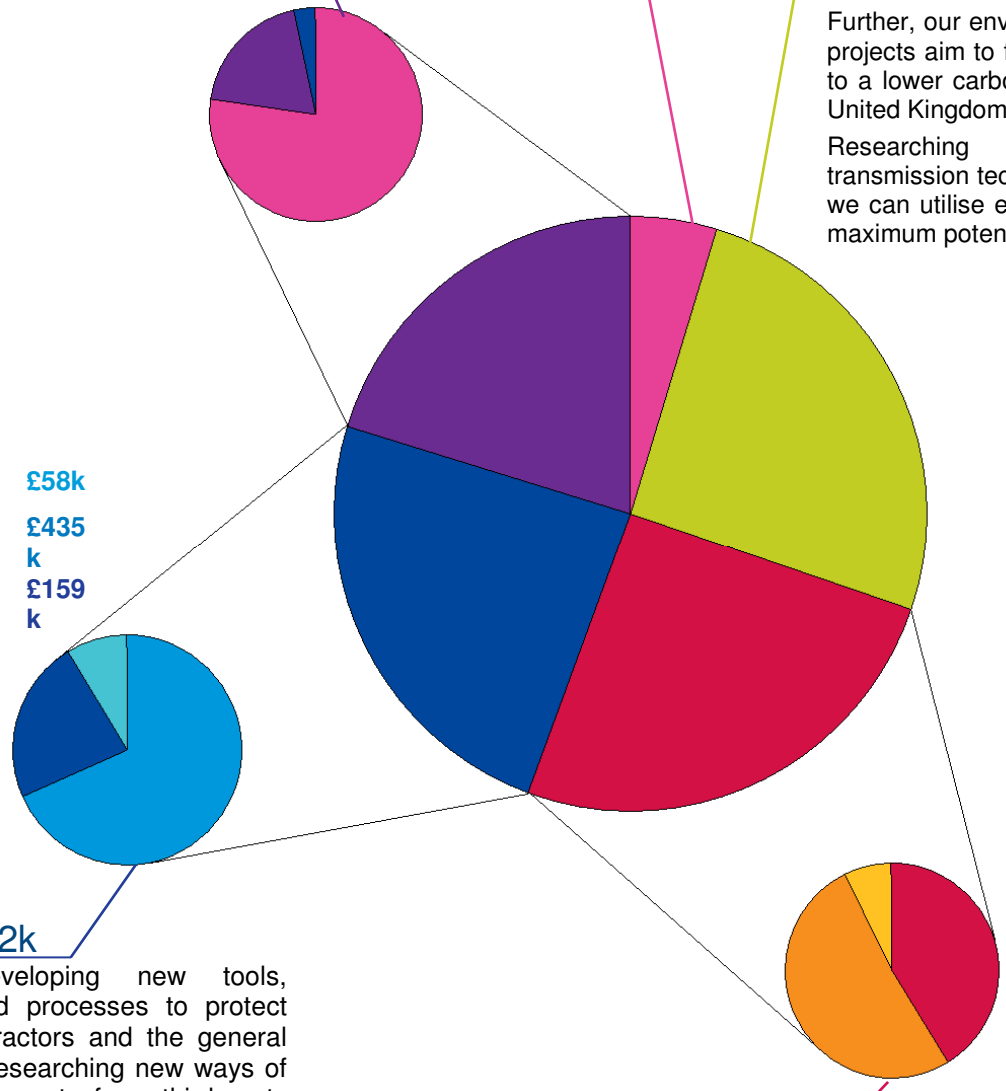
New Materials and Technologies	£440k
Long Term Research	£110k
Pipeline Re-use	£19k

Environment £719k

We seek to minimise our impact on the landscape and reduce our carbon footprint. We are working to reduce the volumes of gas vented during operational procedures.

Further, our environmental innovation projects aim to facilitate the transition to a lower carbon energy mix for the United Kingdom.

Researching new and existing transmission technologies means that we can utilise existing assets to their maximum potential.



Third Party Interference	£58k
Infrastructure	£435k
Safe Working Practices	£159k

Safety £652k

We are developing new tools, techniques and processes to protect our staff, contractors and the general public. We're researching new ways of protecting our assets from third party interference. 68% of our gas safety spend went to infrastructure research. This research enables us to maximise the efficiency of our use of assets, without compromising their integrity.

Reliability £717k

Optimising Asset Management	£294k
Gas Quality	£372k
Capacity and Capability	£51k

Knowledge Transfer

Engagement

With an increased focus on innovation within National Grid the IFI team have supported a number of key conferences to highlight our current innovation work. The Transmission and Distribution innovation teams joined National Grid's senior leadership (UK and US) conference that took place in Manchester in January this year. There were eight projects on display, as well as a set of summary slides covering sixty of the innovation projects. The displays prompted significant interest and many discussions about implementation of innovation within the company and the wider industry.

> "The conference exhibits demonstrated to me that innovation is taking root within the organisation."
>
> Sir Peter Gershon
> Chairman - National Grid

Innovation will be a focus at National Grid's Annual General Meeting, opening the innovation projects up to a wider range of stakeholders and interested parties. We also have very strong engagement on Innovation with organisations such as the Energy Research Partnership, ENTSOE, EPSRC, UK universities, Customers, our equipment suppliers, the Scottish TOs and others. National Grid will present at the distribution companies Low Carbon Network Conference in order to assist further in the dissemination of information, sharing knowledge across the whole value chain.

Asset Management Matters


AssetManagementMatters 03

01 A message from Mike Calvou
02 Got something to say: Gas@200
03 Innovation in Action
04 Investment Process Data Cleanse
05 L&D help shape new Marine Plan
06-07 COMA compressor seal innovation
08-09 Strategic Asset Management (SAM)
10 Construction Update Desk Drop
11 Energy Matters
12-14 Field focus – Gas
15-17 Field focus – Electricity

Innovation **in Action**

"Innovation" refers to how we play our part at the heart of the major changes in the energy sector; doing things differently and doing different things.

Over the last financial year, National Grid has been active in 149 transmission innovation projects, 40 in Gas Transmission and 109 in Electricity Transmission.

Details of these projects are recorded in › National Grid's Transmission Innovation Funding Incentive (IFI) Research and Development (R&D) program report ‹

We will be highlighting 3 of these projects in each edition of Asset Management Matters.

Acoustic Emissions from HV Overhead Conductors
A world leading project aimed at understanding the causes of excessive noise from overhead line conductors and how this might be alleviated.

For more information see page 83 of the › IFI program report ‹

Ratings of cables in tunnels (ROGIT)
To review the rating methods used to design cable tunnels by assessing existing operational data, including Distributed Temperature Sensor (DTS) data and to develop a specification for a rating method for cable tunnel installations with independent cable circuits.

For more information see page 126 of the › IFI program report ‹

Combined Geophysics Tool for Pipelines Routeing and Risk Assessment
To trial new approaches to subsurface (geophysical) surveying, which will reduce the cost of pipeline construction projects caused by unforeseen or avoidable sub-surface ground conditions.

For more information see page 319 of the › IFI program report ‹

Innovation isn't just about deploying new technology, it is more often a series of smaller, incremental changes which add the most value and a lot of these, such as the Oil Management Unit's (OMU) new top up tanks for Transformers, come from our people.

If you have an innovative idea to help us improve our processes/systems email › Box.TransmissionRD.Proposals ‹ starting the subject with the word IDEA.

If you would like to know more about R&D projects please contact David Fidler, R&D team

Internal communications to all staff have increased over the last year, kicking off with an issue devoted to innovation in November 2011.

The IFI team have worked with National Grid's Communication Team to establish an ongoing summary page on innovation in every issue. The articles showcase three current innovation projects setting them in context within the business and highlighting the potential impact.

An example of an innovation article is shown on the left highlighting the project with a picture, and a brief description as well as providing electronic links to further information and contacts.

Student wins awards

A PhD student working on a research project funded by National Grid at the University of Strathclyde won the Best Poster prize at 'Energy Harvesting 2011' held at the IET, Savoy Place, London on 7th February 2011. Minan Zhu presented an overview of research being carried out with colleagues Martin Judd and Nina Roscoe into harvesting energy from the ambient 50Hz electric and magnetic fields in substations with the aim of making condition monitoring sensors 'self powering.' This capability has the potential to eliminate batteries and cabling when combined with low power wireless communications technology.

Focus on Electricity Innovation

Hydro Québec

Focus : Connections | System Access
TRL : 7-8
Project Title : OHL Robotic Technology

National Grid is collaborating with Hydro Québec organizing the first trial of Line scout in Europe.

In addition National Grid is working in collaboration with Hydro Québec to add additional capabilities to Line scout which will be beneficial to both companies.

Through the ITOMS (International Transmission Operations and Maintenance Study) conference early last year, Phil Haywood, Benchmarking and Best Practice Technical Leader learnt about a Robotic Technology that had been developed in Canada known as “LineScout”.

The LineScout is a remotely operated overhead lines inspection and maintenance robot that has the capability to work on live lines at voltages up to 735 KV. It is capable of inspecting overhead conductors and fittings, using four on board high definition cameras. Images are transmitted to a remote ground base where they are viewed and saved for future analysis.

As well as inspecting the lines, the technology can perform a number of maintenance operations including recovery and relocation of bolted damper assemblies, temporary conductor strand repairs and the electrical resistance measurement of conductor joints.

All these activities are undertaken while the circuit is live, controlled by an operative at ground level. It also has the ability to make its way around obstacles such as spacers or suspension insulators. The technology provides a safe mode of operation and removes the need to gain access to the system to undertake these activities. With the support of IFI funding, we have been developing an active working relationship with Hydro Quebec which included the Linescout being brought over to the UK to be demonstrated on our system in September 2011.

The event was hosted by the Overhead Lines Field Support team and the Bramley Overhead Line delivery team in Maintenance Delivery Electricity (MDE) who had the opportunity to work closely with their Canadian counterparts. Peter Henness from the Bramley Line team said, “The technology behind the LineScout is great. I think there will be lots of applications we can put on it for National Grid’s use.” representatives from across the business had the opportunity to attend a live demonstration of the Robot over the two days.

National Grid is working in collaboration with Hydro Quebec on present and future innovative projects. Serge Montembault, LineScout Project Manager for Hydro Quebec said, “We are very proud to see LineScout on the National Grid Transmission network. We are looking forward to a fruitful collaboration and a growing relationship with National Grid.”

After attending the demonstration David Wright, Electricity Network Investment (ENI) Manager said, “LineScout is amazing. The camera quality and speed with which our linesmen deployed it was breathtaking. A great new tool for assessing the condition of our overhead circuits and a key process safety improvement for our most difficult to reach, river/motorway crossing spans.”

Focus on Electricity Innovation

Moss Screens

Focus : Safety | Safe Working Practices
TRL : 8
Project Title : Rapid Deployment Ballistic Screens

Over the last year National Grid has developed a freestanding ballistic screen. This screen has been tested on a firing range and is capable of stopping all fragments of porcelain at a distance of 10 meters from the point of incident. The test launch velocity is up to 300mph.

Over the last year, Asset Engineering (Condition Monitoring) have been doing extensive ballistic testing into a new type of high energy absorbing material that is non metallic, light and thin (less than 56mm thick). This work has been completed to deliver an inexpensive, effective and easily deployed ballistic screening module that is easily capable of withstanding the resulting debris from a typical catastrophic failure of porcelain clad HV transmission assets such as those seen in FMJL CTs.

The materials used to create the screens are a combination of high strength GRP grids which are then plated with a sheet of 6mm polycarbonate. The screens are easy to assemble, relatively lightweight & 80% recyclable. Fully non metal, it can be used within a live substation.

The screens have been tested under extreme conditions withstanding porcelain fragments with launch speeds significantly above those expected by substation equipment failure modes. The trials have tested the screens with launch speeds over 300mph and fragment masses of over 1kg. At 10 meters distance, under the extreme conditions trailed, the screens still prevented any ceramic from penetrating them.

The main ballistic testing of the prototype screen module (measuring 4m tall by 3m wide) was conducted by utilising an old OHBR support column. All the fragments were completely repelled and disintegrated upon impact with the screens.

The sequence opposite shows fragments of up to 1kg hitting the test screen at speeds ranging to over 300mph from a controlled detonation on a firing range.

A tube of liquid high explosive was detonated inside the column, throwing out porcelain fragments from small $1cm^3$ sizes right up to large 1kg fragments. Fragments were discovered 120m from the detonation site, apart from in areas shielded by the screen. The screen itself was undamaged.

Ballistic testing set up screen distance 10m

Test Detonation

Test Impact

Focus on Electricity Innovation

Rogowski Coils

Focus : Strategic | New Materials and Technologies
TRL : 7
Project Title : Non Conventional Instrument Transformers

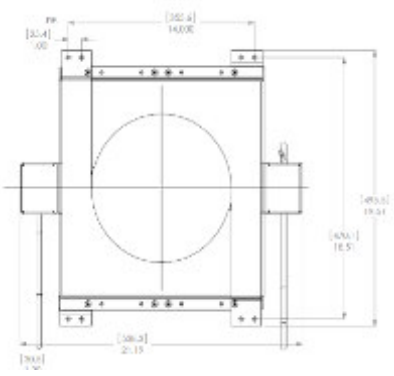
Trailing new sensors that can be utilities by National Grid which are more suited to cope with the complexity of hybrid lines.

Public perception towards OHL and limitations on rights of way in populated areas could potentially lead to increased construction of Cable only and Cable & OHL hybrid circuits in future. This situation presents a unique challenge for cable protection systems, especially on Hybrid circuits, as the protection system must differentiate between cable and OHL faults to ensure the continued reliability of the power system.

Rogowski-coil installed at Pitsmoor 275kV Substation Cable Sealing End

Current practice in National Grid is to implement two main unit protection schemes sourced from two different suppliers by using conventional iron core CTs (Current Transformers) for 275kV and 400kV cable systems. CT installation and maintenance on cable circuits is immensely cumbersome due to the bulky structure of CTs and space constrains associated with cable tunnels and trenches. CTs could fail disruptively and pose potential safety hazard if inadvertently open circuited whilst in service.

To address these issues, a pilot installation of Rogowski coil current sensors with an associated Unit Protection from Cooper Power, was successfully installed and commissioned by National Grid MDE (Maintenance Delivery Electricity) staff on the Pitsmoor to Wincobank cable circuit on the 25th May 2012. The novel protection solution uses Rogowski coil current sensors and one multi function relay at each end of the cable to perform cable differential protection. Installation of the system required no changes to the existing high voltage system design. Only minimal outage time of the circuits was required for the commissioning of the system. The Rogowski coil split core design allowed for installation without disconnecting the power cables. The relays communicate over a Synchronous Digital Hierarchy (SDH) network. This is the first installation of this kind in the world. Analysis of the relay performance indicates that the scheme is operating as designed. This trial will continue until the end of December 2012.



Physical dimension of Rogowski coil.

Rogowski coils offer a number of significant benefits over traditional iron core CTs. Each weighs only 2kg and contains no porcelain or oil. This makes them safer to work on and more environmentally sustainable. They provide metering class (0.2%) accuracy, wide bandwidth, low distortion with a linear transfer function and no saturation characteristics. The accuracy of the coils allows the relays to be set more sensitively.

A project with ABB is currently at the trial installation and commissioning stage for GIS (Gas Insulated Systems) type feeder protection on Bodelwyddan, Deeside and Pentir 2 circuit. Further evaluation of the technology will be carried out to assess the suitability of Rogowski coils for the protection of other types of plant (e.g. Transformers, Busbars etc).

Focus on Gas Innovation

Non invasive pipeline inspection

Focus : Safety | Infrastructure
TRL : 6
Project Title : Magnetic Tomography Method Pipeline inspection System: Evaluation & Validation

Potential to inspect buried pipelines from above ground to locate metal loss and stress features

Techniques for inspecting buried pipelines

National Grid Gas (NGG) currently utilises a number of techniques to inspect buried pipelines. In addition to the In Line Inspection (ILI) method, performed using intelligent pigging, there are several non invasive above ground inspection techniques. This project is investigating the potential of a new non invasive inspection system, the non contact Magnetic Tomography Method (MTM), which has the potential to locate areas of metal loss in buried pipelines from above ground.

The goal of this IFI project is to develop and carry out a thorough evaluation of MTM to better understand the benefits of its use by National Grid. During the phased evaluations, GL Nobel Denton has been working closely with the UK MTM supplier to conduct onsite test inspections and blind trials to define MTM's capabilities to locate and quantify anomalous features identified in buried pipeline.

Potential benefits of the MTM system

In the event that the non contact Magnetic Tomography Method (MTM) gathers reliable information on pipeline conditions, it will provide National Grid with a non invasive technique to complement the Inline Inspection (ILI) method, which is currently the only available technique capable of locating and sizing metal loss features in buried pipelines. Using the MTM technique in conjunction with data gathered from Inline Inspections (ILI) could result in a reduction to the quantity of, and costs associated with, digging down to further investigate sub critical pipeline defects.

Uniqueness of the MTM system

This new technology has been developed to be an innovative, non intrusive and non contact method of above ground pipeline inspection with the potential to locate pipeline material anomalies, characterise these anomalies and forecast the need for follow up actions.

Warburton Pipeline showing locations of green anomalies identified during inspection

MTM measures distortions in the earth's magnetic field due to the presence of buried objects, such as a pipeline. Areas of high stress in the pipeline cause significant distortion of the earth's magnetic field surrounding the pipeline, and these areas of distortion can be detected from the surface. Excavation of the identified areas can then be made to determine the cause of magnetic distortion.

The MTM technique claims to have several key advantages over other above ground techniques. These include:

- The ability to reveal metal loss features and cracking in buried pipeline
- Negating the need for advanced preparation or changes to operating conditions
- Use of GPS within the system to accurately locate anomalies on a pipeline
- Suitable for use on any pipeline regardless of the type of construction, type of medium transported, and presence of flow
- MTM does not magnetise the pipeline

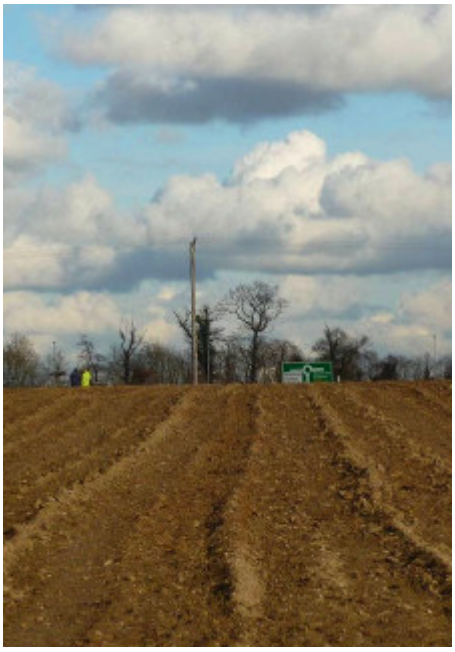
In addition to these advantages, the MTM technique will be of particular benefit where metal loss features occur under disbonded coating. Although these are detectable using ILI, none of the surface inspection techniques currently employed by National Grid are capable of locating coating disbondment features.

Onsite test inspections

A set of onsite test inspections were conducted between February and April 2011. During this time the MTM system successfully inspected seven sections of pipeline, measuring a length of over 9km. The pipelines were selected based on recent inspection of the sections using the In Line Inspection (ILI) method, allowing for comparison of the ILI data with the MTM trial outputs.

Following the initial MTM onsite trials an inspection report was produced. Results from the first MTM trials were compared directly to ILI results by overlaying both data sets onto a pipeline map created on Uptime, a tool currently used to asset with the management and storage of detailed information on transmission pipelines. This mapping exercise enabled results to be directly compared, and has confirmed that there is a correlation between the locations of pipeline anomalies from both data sets.

The MTM system detected nearly twice as many anomalies as the ILI method. The majority of these anomalies are believed to be stress deformed pipeline sections due to ground movement, which would not generally be detected by the ILI method. Typically the anomalies located by the ILI and MTM systems were found to be within a few meters of each other. There were, however, a number of anomalies located outside of a +\- 15 meter band. This can be attributed to the MTM system's capacity to detect defective sections of pipeline that contain a number of anomalies and sections stressed by ground movements, rather than the detection of small individual anomalies.



Location selected for the MTM trial inspection

Results from the MTM trials were also validated during subsequent excavation and physical examinations of a selection of the seven pipeline sections. Results indicate that the MTM system has demonstrated the ability to locate anomalies during an above ground inspection.

Entering the next project phase

Following the success of the first set of MTM site trial inspections further IFI funding was secured and the MTM system has been improved and upgraded working in collaboration with Leeds University.

The intention of the second phase of trials is to improve understanding of MTM system performance, utilising improvements made to the system since the last trials were undertaken and to identify areas where the system may need to be improved further. The project will inspect ten additional sections of National Grid pipeline, measuring approximately 20km, where anomalous features have been located during In Line Inspection (ILI). Eight of the ten pipeline sections are scheduled for excavation and examination, while the remaining two sections of the pipeline are known to be experiencing stress conditions due to ground movement. All site trials undertaken in 2012 will use the updated Mark 2 MTM system.

The second phase of testing will give increased confidence that the technique could deliver the expected benefits of a non invasive inspection system to the efficient management of the National Transmission System.

Section of excavated pipeline

Focus on Gas Innovation

Maintenance, efficiency, safety and integrity.

Focus : Safety | Infrastructure
TRL : 8
Project Title : Optimization of Integrity Management at Sleeved Crossings

Alternative materials for nitrogen sleeves on the National Transmission System (NTS)

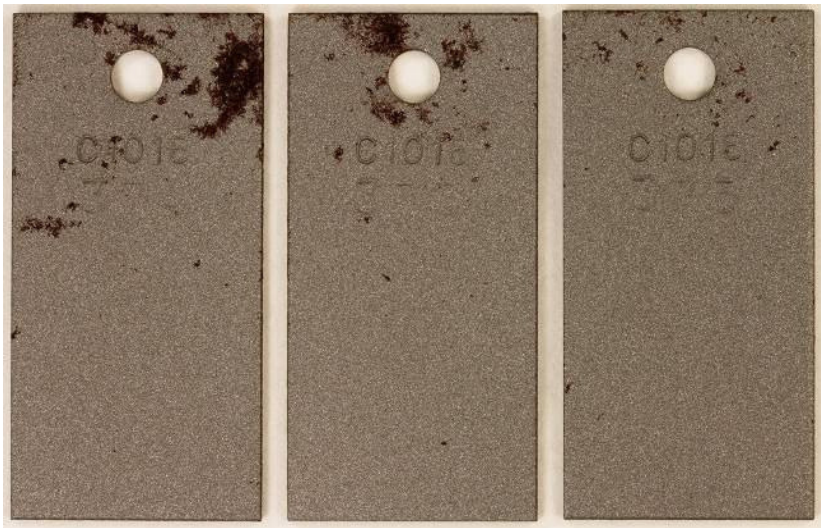
Alternative solutions to nitrogen sleeves

As part of an IFI project in 2009, National Grid began investigating alternative solutions to the use of nitrogen as filler in steel pipe sleeves located at road, river and rail crossings.

Over one thousand of these steel sleeves were installed on the UK National Transmission System (NTS) during the 1960's and 1970's and the successful replacement of nitrogen as a sleeve filler will bring National Grid to the forefront of industry practices in Europe and North America.

Historically, National Grid implemented steel sleeves, in accordance with requirements set out by IGEM/TD/1 (TD1) Steel Pipelines for High Pressure Gas Transmission, to provide additional protection to pipelines crossing traffic routes. Whilst the installation of steel sleeves in the UK ended in 1984, regular maintenance and inspection of the existing sleeves must be carried out to ensure safety and compliance with the Pipeline Safety Regulations 1996, IGEM TD/1 standards and T/PM/Maint/5.

The importance of identifying replacement materials for nitrogen is primarily linked to instances where nitrogen sleeves have failed to adequately retain pressure. This is generally attributed to failure of the steel sleeves end seal, valves and hoses. Potential for corrosion in the pipeline is significantly increased in the event of a nitrogen leak. As a result, these sleeves are considered non compliant and require a costly, time intensive maintenance programme to monitor, repair and re fill the sleeves with nitrogen. There would therefore be significant savings associated with resources and materials currently required to maintain nitrogen sleeves.



Macrographs of steel corrosion coupons

The aim of this project is to carry out research to identify alternative solutions to the use of nitrogen for providing an inert atmosphere and seal within a steel sleeve. During the initial phase of work an in depth review of potential materials was undertaken to determine fitness for purpose. The intent was to outline the implications of cost, ease of installation, ongoing maintenance requirements and the existence of proven operator experience. As well as review the long term performance and overall reliability of prospective solutions compared to current business practice.

As a part of this work, international best practice on sleeve management was explored to understand techniques currently being employed within the European and North American gas industries.

Identifying the right solutions

Eight materials, varying from gels to viscous fluids to gases, were identified as possible nitrogen replacements in the initial phase. All of the materials were selected based on key features such as corrosion control and the feasibility of injection of the material into pipe sleeves through existing connections.

Research on the eight materials subsequently narrowed the list down to four possible solutions. Two were petroleum based compounds, one was a polymer based compound and the other was a vapour phase based solution.

After further analysis and consideration, three of the four materials were short listed for trial installations at GL Nobel Denton. The trial installation provided important data on the properties of the materials and the service of their respective manufacturers.

Steel pipe with an acrylic test sleeve to allow for visual during trial installations of the petroleum and polymer replacement filler materials

Short-listed petroleum filler

Two key physical properties of the replacement filler materials trialed during this project are volumetric shrinkage and corrosion protection.

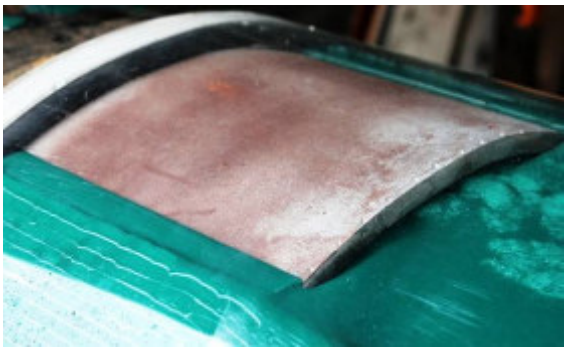
Volumetric shrinkage was evaluated after the initial laboratory examination and based on results from the trial installation and the second laboratory trial. During both of the polymer and petroleum compound trials it was found that the integrity of the fillers inside the required volume is likely to be retained in a field installation. Volumetric shrinkage is not applicable to the vapour phase based solution and therefore did not undergo testing in this area.

Protection from corrosion using the vapour based product was confirmed during testing. The polymer and petroleum candidate fillers have shown to have high dielectric resistance and hence corrosion should be prevented once applied to the surface to be protected.

Field test operations

Following the success of the trial installations of the short listed polymer and petroleum materials, field test operations were scheduled for both materials to be injected into two existing steel pipe sleeves. The pipe sleeves chosen for field testing were identified as non compliant due to their inability to hold nitrogen pressure and therefore require an alternative solution.

During this phase of the project, a comprehensive survey will be undertaken of 126 sites containing non compliant steel pipe sleeves. Based on the results of the polymer and petroleum field trials, the 126 pipe sleeves will potentially be injected with the appropriate replacement material. Completion of this phase of the project is projected for the end of December 2012.



Polymer trial, three weeks after installation of the replacement material

Finance Overview and Benefits of the Portfolio

This section of the report gives the financial information associated with the 2011/12 NG Transmission IFI funded portfolio as agreed in the Innovation Good Practice Guide for Energy Networks (G85).

In year 5 there have been 129 live reportable projects moving through the innovation portfolio ranging from proof of concept through to demonstration projects. The total spend for 2011/12 was £9.37m utilising 99.3% of the IFI allowance. R&D outputs form a key part of National Grid's asset management activities by finding solutions to technical problems, managing risk and helping drive efficiencies.

Benefits are assessed on an individual basis and reported on in the detailed section of the report; the IFI portfolio delivers a balanced program of work which provides an overall positive Net Present Value (NPV). When calculating a project NPV, the costs attributed to the benefits are:

Direct costs– e.g. Costs saved through a reduced planned capital expenditure or targeted maintenance.

Avoided costs- e.g. Through deferred investment, reduced failures and establishing true condition of equipment potentially improved ratings.

The IFI program also delivers a range of non financial benefits. While these produce negative NPV's they are still key to providing benefit to customers. The inclusion of these elements helps to create a more accurate picture of the true benefit that the innovation program provided to National Grid. These include but are not limited to:

- **Safety**
- **Environmental**
- **Network Performance**
- **External risk**
- **Knowledge transfer**

The overall NPV for the current Electricity Transmission portfolio is £17m. The overall NPV for the current Gas Transmission portfolio is valued at £11m.

Electrcity IFI	
IFI Allowance	**£6.583m**
Number of Active Projects	**97**
External Expenditure	**£5.648m**
Internal Expenditure	**£0.926m**
Total Expenditure	**£6.574m**
Anticipated IFI Allowance (For 2012/13)	**£7.168m**
Carry over 11/12-12/13	**£0.009m**

Gas IFI	
IFI Allowance	**£2.849m**
Number of Active Projects	**32**
External Expenditure	**£2.557m**
Internal Expenditure	**£0.234m**
Total Expenditure	**£2.791m**
Anticipated IFI Allowance (For 2012/13)	**£3.278m**
Carry over 11/12-12/13	**£0.058m**

Looking Forward

As we move into the last year of the Innovation Funding Incentive (IFI) we are developing our thinking and future portfolio in line with the Innovation Strategy submitted to Ofgem in support of our RIIO-T1 submissions. National Grid has been a keen contributor to Ofgem's Innovation Working Group and will continue to engage over this year. Engaging with our customers and stakeholders together with collaboration with other utilities is seen as key to innovation success and we support the development of improved communications through the Energy Networks Association and European working groups, for example ENTSO-E.

Our aim is to maximise the benefits from the current portfolio during the remaining price control period, as well as initiating initial studies that could potentially lead into the development of Network Innovation Competition projects to take forward under RIIO-T1.

We expect to utilise the full IFI allowance in 2012/13 on planned existing and new work proposals.

Ofgem's Project Discovery estimated that £200bn will need to be invested in the UK's energy sector over the next ten years, including ~£30bn in networks to replace ageing assets and connecting new sources of energy. To deliver this to time while offering value for money for the end consumer we need to be innovative in the way we deliver these projects.

Embedding a culture of innovation is pivotal in delivering the outputs required by our stakeholders. Innovation needs to drive learning in network businesses. National Grid has increased internal communications surrounding innovation as well as looking to trial social media style communication forums which uses a peer review system to rank innovation ideas.

We are in a unique position to safeguard the environment for future generations through the infrastructure that we provide and services we deliver supporting a lower carbon future.

As we progress through this decade, we will need to invest significantly in assets and technology.
Innovation will be key to establishing the efficient, effective, economic and sustainable solutions to the upcoming challenges, for example, overcoming the barriers (both cost and technology) to HVDC connections.

We need to convert our transmission assets into a more flexible system, which will facilitate delivery of the Government's UK carbon targets and ensure the safety of the environment for future generations.

> *"National Grid Transmission has a very organised and disciplined approach both to the management of research & development and to the introduction of new technology."*
>
> Mike Cahill, Deputy Regional Manager, Utilities for Lloyd's Register

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