nationalgrid

Network Innovation Annual Summary 2017/2018

Electricity Transmission

Contents

Welcome to the innovation annual summary for 2017/18

“Innovation is one of the pillars raising National Grid’s performance, helping us shape the energy markets for the future.”

David Wright
Director
Electricity Transmission
Group Chief Electricity Engineer

As an engineer, I have grown up understanding the true value of innovation to society, and have seen how major innovations change the way we live and do business. Whether it’s been the creation of the iPad in 2010, or SpaceX landing a first-stage rocket on an ocean-going drone ship in 2016, innovation done properly transforms people’s lives. My vision for our customers is not to drive incremental change through our innovation programme, but to change electrical transmission networks for the good of society. Our research is driven by the belief that one day we will change the very idea of how we interact with a transmission network and what it can do for our world.

How do we make that new vision of the future network a reality? We begin by solving the engineering problems of today. For example, we have delivered the world’s first 400kV gas insulated electricity substation that uses an alternative gas to SF_6. We are also looking at materials that extend the lifetime of our assets (see page eight), investigating methods to reduce the amount of work we carry out on sites and investigating technologies to deliver cost efficiencies. Then there are research projects that continue to increase safety for both workers and the public, and reduce the outage time of networks, like the portable earthing vehicles that can be quickly deployed to our sites.

During the 2017/18 period, we’ve invested over £4.6m into projects through the Network Innovation Allowance (NIA) funding mechanism. Our innovation projects involved more than 85 people working on NIA, NIC and Totex projects. That’s over 14,000 hours on NIA and NIC projects and a total of more than 15,660 hours on Totex projects from world-class researchers and engineers. These hours have contributed towards making sure we have the right people working on the 49 projects that were underway at the end of April 2018. We can also ensure we successfully and effectively implement the output of those projects we have closed off. During that 2017/18 period, these totalled 34.

Looking towards the immediate future, at Deeside we are converting an existing 400kV substation into a facility for testing and evaluating solutions without putting the customer supply at risk. The site gives us and other organisations a place to trial technologies and new practices. And it means we can support the start-up community and help small to medium enterprises succeed in an increasingly competitive market. Deeside, the first of its kind in Europe, saw us securing £12m in funding from Ofgem in 2015 and putting £14m of our own money in. Projects we have started at the facility this year include trialing a retrofit for cable sealing ends, non-invasive tower foundation inspections and zip-up scaffolding solutions that offer time-efficiency savings and improved safety for access to high-level asset components. You can read more about these projects and their status from page 20.

With the rise of autonomous, electric vehicles and distributed battery storage technologies we need to take a flexible, evolutionary approach to delivering the electricity transmission network in the coming decades. Flexibility and evolution can only come from working with the broader engineering community and understanding the whole picture. So, we not only look to our own people to embed innovation into our everyday practices; we engage with external experts who can help us make a difference for customers and end-consumers. On page six you can read about our partners and the research we are doing with business and academia.

Innovation has always been in the DNA of National Grid and over the next few pages I’m proud to share the work that we have been doing to continue that tradition. The future starts here.

David Wright
Director
Electricity Transmission
Group Chief Electricity Engineer

Altering our DNA and investing in the future

"Gas Insulated Lines (GIL) provide greater flexibility to meet demands, such as the increasing desire for underground power transmission lines, especially in areas of outstanding natural beauty like national parks or highly densely populated areas like cities. The potential deployment of enhanced GIL solutions is viewed by both National Grid and Siemens as a potential game changer in the global transmission sector."

Matthias Müller
Director
Power Transmission Lines
Siemens

Innovation is in our DNA and as such, we are continuously reshaping ourselves for the rapidly changing energy landscape.

This landscape is seeing an increasing amount of renewable energy sources come online and transformational changes to the transport and energy infrastructure. This is also reflected in an increased demand from household and commercial consumers to match the fast-paced digital world they live in and the drive for reduced carbon emissions. It has become obvious that the transmission network needs to reflect that demand.

Our approach has been to broaden our portfolio of innovative projects and reshape our business and innovation processes to be agile enough to explore a wide range of solutions to drive costs down. All while continuing to identify new ways and technologies to improve the environmental and safety benefits of our work.

Over the past year, we've invested £4.6m into 49 NIA projects. But growing our business means we must look beyond the NIA and NIC funding frameworks and invest our own money to develop long-term solutions.

One example has been our investment of £20m into a £40m initiative to research and develop the use of Gas Insulated Lines (GIL), as well as new gases with global warming potential of less than ten, for transmission purposes as part of the first European Innovation Partnership with Siemens. It is also an example of how we are playing our part in transforming the way our industry thinks about decarbonisation and sustainability.

This year we have also increased our engagement with our stakeholders and suppliers, at both national and international level, because the future energy network will also be impacted by what happens outside our area of influence. This has led us to develop a new strategy where we focus our research efforts within value themes, so we ensure our spending creates value for customers.

Official signing of the GIL Innovation Partnership January 2018. Clockwise from top left: Carl Ennis, Managing Director, Energy Management Division, Siemens; Simon Harnett, Head of UK Procurement, National Grid; David Wright, Director ETO, National Grid; and Miko Düsel, Chief Executive Officer of Business Unit Transmission Solutions, Siemens.

Innovation consumer value themes

The best way of ensuring we have an aligned and broad portfolio of research is to channel it through four customer value themes. These are: managing assets, efficient build, service delivery and corporate responsibility.

Managing assets

£3.44m

spend in 2017/18

We're constantly looking for ways to increase the lifespan of our assets. During the 2017/18 period, we spent £3.44m understanding what can be done to increase their lifespan and performance. The more we know, the better we can maintain assets at the lowest cost and with the least amount of disruption to our customers.

Efficient build

£1.34m

spend in 2017/18

We're continuing to reduce the cost of building new infrastructure. Examples of where we've invested the £1.34m during the 2017/18 period include trialling new materials and products, finding equipment that can be used more flexibly, and improving the design of the network.

Service delivery

£0.24m

spend in 2017/18

As the transmission network changes, we find new ways to provide value to our customers and consumers. The 2017/18 investment of £0.24m has helped our understanding of present and future expectations, so we can develop the right products and services.

Corporate responsibility

£0.84m

spend in 2017/18

Researching and developing safer working practices is a critical element of delivering network reliability. Our investment of £0.84m in corporate responsibility projects in 2017/18 included looking at the entire build and maintenance process. This helped to find safe, efficient scaffolding-erection techniques, and reduce noise pollution on urban substations.

Working with partners

Any modern business that wants to deliver the best value to its customers must put collaboration at the front of its strategy. This is why we, at National Grid Electricity Transmission (NGET) have been building partnerships with the best people in the engineering community.

"Working with the academic partners allows National Grid to leverage their innovation funds, providing additional benefit to the industry and our consumers."

Ian Cotton
Professor of High Voltage Technology
The University of Manchester

"Our long-standing partnership has meant technical and skill sharing with National Grid; including highly trained students and staff, mitigation of safety voltages, and trials of alternative gases to replace SF_6."

Manu Haddad
Director
Advanced High Voltage Engineering Research Centre
Cardiff University

Collaboration widens our perspective of the industry, increases our knowledge and at the same time means we can share our experiences and insights with the rest of the engineering community. It also guarantees we are aligned to deliver the best value for consumers and stakeholders.

Recent examples of collaborations include the development of an alternative to SF_6, known as Green Gas for Grid (g^3) with GE Grid Solutions. This led to the delivery of the first 400kV electricity system with an SF_6 alternative. From the success of the work, we came to realise there are several other potential alternatives to SF_6 and have been collaborating with 3M, Siemens and both Cardiff University and The University of Manchester. You can find out more about our research and testing of alternative insulating gases on page 10.

We want to develop an alternative to SF_6 with a Global Warming Potential (GWP) of less than ten. The GWP scale, or ratio, was developed for comparing the global warming impacts of different gases, where Carbon dioxide (CO_2) is used as the reference gas with a GWP set equal to one. GWP values allow us to compare the impact of emissions and reductions of different gases.

We believe that a proactively managed portfolio of projects at different technology readiness levels is key to deliver sustainable innovation. We want to keep the work flow full of new ideas; they are the basis for innovation. Universities are key in this area, both from the point of developing new ideas and providing state-of-the-art facilities. We currently have three strategic academic partners: The University of Manchester, Cardiff University and the University of Southampton. We also have projects running with 17 other academic institutions across the UK. In the coming year, we are looking at increasing our strategic relationships both nationally and internationally.

The £40m Innovation Partnership with Siemens to research and use Gas Insulated Lines (GIL) on the electricity transmission network has, to date, allowed us to develop a new way of collaboratively working with our international partners to drive the industry forward. We will be looking at rolling out this co-creation initiative further with both suppliers and customers in the near future.

Our collaboration extends to our involvement with initiatives across the UK. One of these is FLEXIS, a £24.5m Welsh university (Cardiff, Swansea and USW), industry and local government partnership researching the decarbonisation of energy systems. Hywel Thomas, FLEXIS Lead Principal Investigator, said: "Given the importance of National Grid in the electrical energy sector, we highly value our partnership in the areas of environmentally-friendly electrical power plants and insulation, liquid soil and smart geogrids. We're very grateful to have Dr Iliana Portugues, Head of Innovation, on our Advisory Board. Her influence is important in directing our future demonstrator work."

Conferences

Euro TechCon 2017 (November):
We attended the 2017 Euro TechCon in Glasgow during November 2017. We gave a presentation on how the Deeside facility will accelerate the roll-out of new technologies and services.

LCNI 2017 (December):
The LCNI (Low Carbon Networks and Innovation) conference in December 2017 was, once again, a great opportunity to talk to our stakeholders, explore new opportunities and gain valuable feedback on the projects we showcased on our stand. The conference was a chance to meet and discuss potential collaborations with network operators, academic institutions, suppliers, generators and manufacturers on future innovation projects.

Future Networks Conference (April):
In April 2018 we presented a talk on driving value through innovation at the Future Networks Conference in London.

Future of Utilities (July):
In July 2018 we talked about the digitalisation of our industry and how innovation is shaping the future at the Future of Utilities Conference in London.

Out and about

As you read in the previous section, we place collaboration and partnerships at the centre of our approach to innovation. This means we can be open to learning different ways of thinking and discovering new points of view. It also allows us to share what we learn from our innovation work with industry and academia and help the shaping of our industry.

Our colleagues regularly attend and take part in conferences, events, and high-profile industry meetings across the country and abroad. While it isn't always possible to capture the many informal conversations and breakout sessions where knowledge sharing takes place, a review of some of the conferences and meetings we have attended this year gives an understanding of where we have been sharing our insights.

Call for proposals

Gas Insulated Lines innovation partnership
In early 2017 we launched a procurement event in relation to the development, production and installation of Gas Insulated Lines, tunnelled, direct or non-direct buried installation and Replacement Gas using innovative technologies. This bespoke contract combines three elements within one contract, which helps both us and suppliers to co-invest in high-risk innovations with an incentive around their success. This novel contractual arrangement addresses one of the main concerns we have heard from many of our innovation stakeholders who feel the barrier for adoption of innovation is high and difficult to overcome.

Masters of innovation competition
We launched the Masters of Innovation competition in 2017 as an open call to invite engineers from industry and academia to submit their ideas to be considered for research funding.

There were three categories for the submissions:

- **Challenge one:** cable asset health indicators.
- **Challenge two:** transforming civil infrastructure for all transmission assets.
- **Challenge three:** solutions to increasing transmission boundary power flows.

The judging team received 25 submissions that went through a review and presentation process and 11 projects were chosen. These have now been funded through the Network Innovation Allowance (NIA) scheme and will go through to the formal sanction process.

Dissemination events

Novel acoustic attenuation:
We shared the outcomes of our research into reducing noise pollution with internal and external stakeholders at Walton Hall in May 2018. Invited guests included Sonobex, SP Energy Networks, WSP, Merford and Northern Power Grid.

MIDEL 7131:
In July 2017 we invited representatives from SSE, Energy Networks, WSP, PB World, M&I Materials, The Environment Agency and Siemens to National Grid House. We shared updates and outcomes of our research on the uses of MIDEL 7131 (find out more on page 13).

Updates on key projects

In the previous section, we covered the events and conferences where we shared updates on our projects and invited engineers to take part in the Masters of Innovation contest. Over the next few pages you can read more about some of those projects and where our collaborations and research have led us. As you will see, the research has uncovered a wide range of solutions to engineering and environmental issues that are going to extend the efficient lifespan and cost-effectiveness of our assets.

How advanced materials are improving the future of our network

Title:
Feasibility study on the application of advanced materials

Project reference number:
NIA_NGET0176

Consumer value theme :
Efficient Build

Innovation in numbers:

480km

of line analysed

Faults on our equipment can often result in system downtime while repairs are carried out. If we want to maximise the life and performance of the network, using advanced materials could significantly improve reliability and reduce the environmental impact of our assets.

The first step has been to work with The University of Manchester to review the current research literature. We identified over 50 potential solutions for improved sustainability and network resilience. These ranged from the need to increase the ratings of conductors, to new materials for monitoring the performance of assets and improved materials for the network's civil infrastructure. Potential solutions included using graphene and materials that respond to their environment or self-heal.

The biggest impact is likely to be seen in the ratings of overhead lines and buried cables, where advanced materials and processes could increase performance by around 40 per cent and 330 per cent respectively. This could meet the increased demand for electricity as the UK plans to phase out diesel and petrol vehicles in favour of electric vehicles by 2040.

Over the next 12 months we will be selecting the most promising projects to develop further.

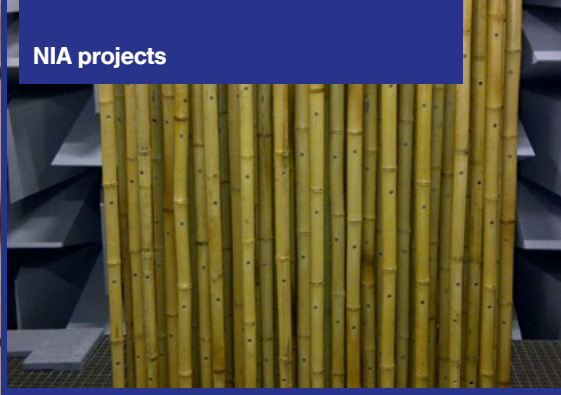
Increasing the lifespan for overhead lines

Title:
Novel methodology for assessing environmental exposure of OHL routes

Project reference number:
NIA_NGET0206

Consumer value theme :
Managing Assets

This year we completed a research programme to extend the life of our overhead line fittings. We now have a greater understanding of how the environment affects our overhead line spans and how the energy input from wind-induced motion and corrosive compounds increases the deterioration rate of conductors and fittings. We can now fine-tune our asset replacement plans and target spending on the assets with the highest risk of developing defects and failures. So far, we have analysed 480km of line, reducing our RIIO-T1 spending by £72m from last year.



Using bamboo to reduce noise involves drilling holes in the bamboo. By altering the radius and length of the hole, the resonant frequency can be changed. This allows you to 'tune' the bamboo and reduce the frequency of noise you're trying to control.

Title:
Novel acoustic attenuation feasibility study

Project reference number:
NIA_NGET0203

Consumer value theme:
Efficient Build

Keeping the noise down for the neighbours

Many of our substations are built near or right in the heart of communities. To understand how we can reduce the impact of transformer noise on those communities, we commissioned a report on novel, cost-effective and practical solutions. We selected three options from the report to install and test. These were a bamboo noise barrier, tuned to reduce low frequency tones associated with substations, an active noise control system that works on the principle of phase cancellation and a noise enclosure with potential to deploy quickly that uses fewer resources than current options.

We are now working with the researchers and suppliers to develop these for trials at our substations.

Title:
Offline Substation Environment for the Acceleration of Innovative Technologies (OSEAIT)

Project reference number:
NGETEN02

First test area complete at Deeside

Preparation of the Deeside project has progressed significantly over the past year. Design, development and tendering for the overhead line (OHL) test area has been completed with the construction contract awarded in May 2018. Construction is due to finish in April 2019. This important milestone will bring the first operational area into service so that project trials can begin. You can read the full report on page 17.

Building our understanding of EMFs

Title:
Identify opportunities and developments in EMF research

Project reference number:
NIA_NGET0184

Consumer value theme:
Corporate Responsibility

As substations continue to become part of the built environment, public concerns over the effects of Electrical Magnetic Fields (EMFs) on health have risen.

We have been carrying out research to address these concerns through two NIA-funded initiatives. The first was to increase our knowledge and understanding of public concerns through a review of current research literature, engage with researchers and carry out public opinion polls. The other initiative is membership of the Electric Power Research Institute's (EPRI) EMF programme, where our subscription (and that of other companies) supports a broad and balanced programme of research.

We have been investigating and sharing our unique insights into assessing occupational exposure to EMFs with the international scientific community.

Innovation in numbers:

900

calls to our EMF Helpline per year

20,000

unique visitors to our EMF website www.emfs.info per month

Replacing SF_6 to reduce global impact

Title:
SF_6 management and alternative gases

Project reference number:
NIA_NGET0163

Consumer value theme:
Corporate Responsibility

"In addition to the local benefits, the SF_6 alternatives project is an important step in finding alternative gases which are both safer and more environmentally friendly."

Mark Waldron
Switchgear Technical Leader

The unique characteristics of Sulphur hexafluoride (SF_6) make it an ideal insulator for use in high-voltage electrical applications. This is why it has proven difficult to find a substitute in the 40 years it has been used in substation equipment.

The downside is that SF_6 is a potent greenhouse gas with a global warming impact 23,900 times higher than carbon dioxide. Emissions of SF_6 currently make up a large percentage of our carbon footprint.

In the search for a substitute, we have been running a pilot installation of an SF_6-free, 420kV busbar at Sellindge for the past year. Because of this pilot, our confidence in this new gas technology has increased. Monitoring and assessment will continue, ensuring there are no signs of long-term deterioration.

A test rig, consisting of a sample of modern 420kV gas insulated busbar, designed for use with pure SF_6, was commissioned at the University of Manchester. A programme of tests demonstrated that a mixture of Novec 4710 and CO_2 could withstand the equivalent electrical performance that using SF_6 in this configuration would have given.

We have also been working closely with Cardiff University to investigate the use of other alternatives to SF_6, in switchgear, such as Trifluoroiodomethane. This will also further our understanding of the long-term behaviour of a variety of new gas mixtures that might replace SF_6 in the switchgear market. To this end, we recently started a project for small-scale stability tests of these gases under different operating conditions and in the presence of various materials. Measurement of chemical by-products resulting from, for example, exposure to electrical arcing will enhance our knowledge of how to manage these solutions in the long-term.

This is a valuable first step towards replacing SF_6 across the network, but considerable effort and investment is still needed to achieve a fully proven, retro-fitted solution that suits the unique design of many substations.

The trend towards SF_6 alternatives looks set to continue in the future, judging by the increased interest in research from international parties over the past few years. This has been partly stimulated and accelerated by the commercial availability of Green Gas for Grid (g^3) solutions and pilot projects such as Sellindge.

Title:
Portable earthing device

Project reference number:
NIA_NGET0201

Consumer value theme:
Managing Assets

Portable earthing devices are improving site efficiency and safety

Replacing, repairing or maintaining electricity substation assets is a complex process. A key activity is earthing and de-earthing the high-level busbars. The development of the portable earthing device means our staff can now work more efficiently and safely, which reduces outage time and delivers much needed cost-savings to customers.

The motorised device will allow engineers to apply flexible earths to busbars (for all voltages) from ground level, reducing the amount of manual handling needed, and providing greater control. This reduces the risk to workers by removing the need to work at height, which comes with other earthing methods.

At each stage of the project we consulted with stakeholders, exploring the relative merits of several concept designs before the detailed design stage. Following the manufacture and commissioning (including stability and full functionality tests) of a prototype in September 2017, the device was European Conformity (CE) marked as safe to use.

Since December 2017 the prototype has been put through tests at Walpole 400kV substation and used during many outage occasions. This has given us feedback on its performance, strengths and limitations.

The next step is to deploy the prototype unit at more sites for trials and further feedback to improve the design. These improvements will lead to better units being used by us, bringing the benefits to everyday site work.

Title:
Cost effective removal of conductor crossing clearance constraints

Project reference number:
NIA_NGET0198

Consumer value theme :
Managing Assets

Innovation in numbers:

100m

high

Raising the heights of British industry

We believe innovation should not only benefit our own business, but all British industry. When we extended the height of our Tyne river overhead lines we put that belief into action.

In 2016, the Newcastle yard of the Offshore Group, on the banks of the Tyne, was commissioned to build wind turbine foundation structures. However, the existing 130m overhead lines across the Tyne presented a problem. Offshore Group's yard is upriver of the crossing and the commissioned structures were taller than the height of the line (almost 85m tall in some cases). Before Offshore Group could guarantee the yard would deliver the order, they approached us to find a way to increase the height of the line.

Traditional solutions to this sort of problem are often expensive and inconvenient. We designed a novel, cost-effective solution to increase the height of the conductors by five metres. This method has been used before on the network but never on two adjacent towers and never on a 130m river crossing tower. Our design solution gave Offshore Group the confidence that they could deliver the structures and they won the contract.

Outages and land access were secured at short notice and we developed new working methods. The project was completed in June 2017 against a challenging timeline, while still ensuring the safety of everyone involved.

Title:
Digital Substation – virtual site acceptance testing & training

Project reference number:
NIA_NGET0162

Consumer value theme:
Efficient Build

VSATT and process bus technology

As monitoring systems become capable of processing and capturing more data, the need to replace traditional copper connections with digital ones is becoming critical to the future resilience of the transmission network. A digital system with standardised architecture could also improve modelling of supply needs and asset health, along with improved security.

Cost-savings could also be made because of reduced construction time, integration with digital networks and the ability to mix and match the most cost-effective products from a range of vendors.

However, digital connections require standardised communication architecture. So, in 2008 we began developing a standardised architecture known as Architecture of Substation Secondary Systems (AS^3). Working with four different suppliers, we installed four digital protection bays in parallel to conventional bays on the transmission network. These trial installations showed that the performance, stability and engineering process met our requirements.

To further test vendor-interoperability of AS^3, a follow-up project known as Virtual Site Acceptance Testing and Training (VSATT) was launched. To test AS^3-based substation systems in an off-grid environment a laboratory was built at The University of Manchester.

The VSATT project started in September 2015 and ran for two years. We found that integrating solutions from multiple vendors is possible, but it requires further work to ensure the process is seamless. Our results have been shared with suppliers and other stakeholders to guide specifications and configuration design.

Routine use of digital substations is now one step closer, with the first rollout of process bus solutions expected in 2019.

Title:
Environment Containment Solution of MIDEL 7131

Project reference number:
NIA_NGET0178

Consumer value theme:
Efficient Build

"In Manchester, we are particularly proud of the Transformer Research Consortium that sees National Grid work with a range of partners, and has resulted in the delivery of three transformers filled with a fluid that is safer and more environmentally friendly than other oils."

Ian Cotton
Professor of High Voltage Technology
The University of Manchester

MIDEL transformers

The likely increases in the demand for electricity from the decarbonisation of transport and heat are bringing their own unique challenges to modern urban substations. Among them, increasing safety and making the most of the limited space available in inner cities.

One approach has been our research into the use of low fire-hazard, biodegradable and cost-effective liquids (such as synthetic esters) in our super grid transformers (SGTs). These alternatives to commonly used mineral oils remove the need to install and maintain extensive fire protection systems, and consequently reduce the design footprint of the substation.

The result of our research has been the installation of three MIDEL 7131 (a synthetic ester) filled transformers at our Highbury substation and the sanctioning of two more at our Willesden site.

This brings the installation of new and replacement, compact, low fire-hazard transformers on tight urban sites a step closer to being business as usual. Meanwhile, we are working with suppliers to ensure that the price difference from using synthetic ester-filled transformers is low enough to deliver value for consumers.

Shaping up to meet the future

We are continuously exploring new ways of working and shaping our business to meet the challenges of the evolving energy landscape.

“Innovation is a paradox. On the one hand, it can’t be forced or managed in the usual sense, on the other hand, we have to stimulate it and create the preconditions for it.”

Iliana Portugues
Head of Innovation
Electricity Transmission

This year we developed the Electricity Transmission Innovation Strategy to enhance this activity by investigating contemporary ideas to help define and shape the future of our industry, to anticipate our customer needs and give them what they will want. We are introducing new programmes in materials research, digital solutions and electrification of transport at the forefront of our innovation, and helping organisations who, historically, have not been involved with our industry, understand the commercial opportunities from their involvement. Our new strategy looks at how to innovate for the near and distant future, for the customer and society of today and that of 2060. Alongside our research into the needs of the present and future markets, our strategy aims to drive increased and more meaningful partnerships to develop a clear view of the cutting-edge technologies for the years ahead, working collaboratively to drive them forwards at pace.

As such, our plan, while looking to lead new technologies into the marketplace, is underpinned by actively managing and prioritising customer and stakeholder relationships. The adjacent list, while not comprehensive, gives a broad flavour of the work we will be doing to achieve this in the coming financial year. If you want to be involved, please drop us an email at box.ETO.InnovationTeam@nationalgrid.com

- A new Network Innovation Competition proposal focused on the future energy network.
- 2018’s Masters of Innovation competition.
- An increased number of stakeholder innovation events to help us further develop our programme of work.
- A new programme of work around electrification of transport.
- A new programme of work around the effective and efficient integration of energy vectors.
- Create a programme of work for digital transformation, focused on setting up the foundation and platforms necessary that will allow us and our innovation partners to develop novel artificial intelligence solutions to improve the way we do things.
- Continue to drive innovations in the areas of transmission, both under and above ground, developing a strong portfolio of work to drive down costs.
- Begin a new programme of work to deliver targets innovation in conjunction with our customers and stakeholders.

The innovation team

This year, our innovation strategy and plan have evolved to reflect the challenges of the contemporary environment. Equally, we have developed and added new people to the innovation team in the past 12 months to meet these challenges.

Iliana Portugues heads up Electricity Transmission Innovation at National Grid, and joined the team in 2014.

Iliana graduated from the University of Bath with a MEng in Electronic and Communications Engineering, where she also obtained sponsorship from National Grid and the Electric Power Research Institute (EPRI) for her PhD on developing a system for using antennae. Iliana then moved to the University of Strathclyde as a research fellow, where in 2007 she spun out the technology into Elimpus Ltd. In 2010, Iliana went to work as a Sensor Laboratory Manager and Senior Project Manager for EPRI, before moving back to the University of Strathclyde in 2012 as Director of the Power Networks Demonstration Centre.

If you would like to get in touch to discuss developing an idea for the transmission network, email box.ETO.InnovationTeam@nationalgrid.com

Project portfolio

To learn more about the projects, click the title to be taken to the ENA smarter networks portal or visit: www.smarternetworks.org

Project reference	Project name	Partners
NIA_NGET0013	Tablet interface for a SF_6 mass flow top-up device	DILO Armaturen and Anlagen GmbH
NIA_NGET0015	Dinorwig Thermal Cycling and Cable Rating	The University of Southampton, Doble PowerTest
NIA_NGET0102	13kV Shunt Reactor Refurbishment	ABB
NIA_NGET0104	Proof of Concept for IEC61850 Process Bus Technology	ABB
NIA_NGET0018	Potentials and profiles around earth electrodes and opposite-side injection for large-area earthing	Cardiff University
NIA_NGET0025	Feasibility Study for Sustainable Substation Design	Ove Arup and Partners
NIA_NGET0040	Magnetic Models for Transformers	Cardiff University, The University of Manchester
NIA_NGET0043	Live Line Working Equipment	Ashbrook Engineering Ltd, Bond Aviation Group, Bond Helicopters Europe, Eurocopter UK, New and Renewable Energy Centre, Northern Connectors, Oxford Computer Consultants, P&B Weir Electrical, RS Components, The University of Manchester, The University of Southampton, Clydesdale Bank, TTI Testing, Cunningham Design, T.M. Utley Offshore PLC, Du Monte UK, Bridge Engineering UK, Rotary Wing Ltd, Broadcast Media Services, Hiatco, John Werrell & Son Ltd, Airbus Helicopters
NIA_NGET0048	Cables with Long Electrical Sections	The University of Southampton, The University of Manchester
NIA_NGET0056	Humber Smartzone Pilot Project	EPRI, Ampacimon, Invisible Systems Ltd, Global Substation Solutions, The University of Manchester
NIA_NGET0060	Application of DC circuit-breakers in DC Grids	Cardiff University
NIA_NGET0073	Partial discharge monitoring of DC cable (DCPD)	The University of Southampton
NIA_NGET0079	Rapid Deployment Ballistic Screens	Access Design & Engineering, RS Components, Photron (Europe), Doble PowerTest, C3global, Radnor Range
NIA_NGET0083	Cable Oil Regeneration	Enervac Corporation, JSM Group, Midlands Truck & Van, Utilise
NIA_NGET0088	Transformer Research Consortium	The University of Manchester
NIA_NGET0089	Impact of HVDC Cable Operation on Telecommunication Lines	PowerSure Technology
NIA_NGET0090	Cable Extraction	JSM
NIA_NGET0092	Partial Discharge on Existing HV Cable	Elimpus, Doble PowerTest, Prysmian Group, NDB Technologies
NIA_NGET0093	Online Gas in Oil Analysis on Existing HV Cables	Invisible Systems, Doble PowerTest
NIA_NGET0103	Modelling the tape corrosion process for oil-filled underground cables	The University of Leicester
NIA_NGET0107	Stakeholder attitudes to electricity infrastructure	The University of Exeter
NIA_NGET0109	Bushing and Instrument Transformer Test Tap Connection Condition Assessment Tool	Elisys Engineering, Process Parameters, Elimpus, Invisible Systems, GE Grid Solutions (UK), Macintosh Consultancy
NIA_NGET0112	Enhanced AC and DC safety voltage limits assessment	Cardiff University
NIA_NGET0117	Bulk Oil Circuit Breaker Bushing In Situ Refurbishment	NAREC Electrical Networks
NIA_NGET0130	Determining a threshold for magnetophosphenes perception at 50Hz	Lawson Health Research Institute
NIA_NGET0132	UltraWire	University of Cambridge, Outotec, National Grid, Aurubis, Aalto University, CNT ltd, Nexans, AGH, KME, IOM, PSA Peugeot Citroen, Wieland
NIA_NGET0135	Enhanced Sensor Development (iCASE Award)	The University of Manchester
NIA_NGET0136	Impact of Seabed Properties on Ampacity and Reliability of Cables (iCASE Award)	The University of Southampton
NIA_NGET0140	OHL Condition Assessment	Brunel University London, Amey
NIA_NGET0141	T-pylon Structure and Composite Insulator Testing	Europea De Construcciones Metalicas SA, Russell Ductile Castings Ltd, STRI, Valmont SM A/S, EPL Composite Solutions, Allied Insulators, Eaves Machining, Lapp Insulators, SPIE SAG Group.
NIA_NGET0143	Transient and Clearances in the Future Electrical Transmission Systems (iCASE Award)	The University of Manchester
NIA_NGET0147	Condition Monitoring of Power Assets (COMPASS)	The Watt, PSC Group
NIA_NGET0148	Network Reliability Asset Replacement Decision Support Tool	The University of Manchester
NIA_NGET0153	Life Cycle Costing and Value Optimisation (iCASE Award)	The University of Bath
NIA_NGET0160	Feasibility of Risk based Network Planning	The University of Manchester

Project portfolio – continued

Project reference	Project name	Partners
NIA_NGET0162	Digital Substation – Virtual Site Acceptance Testing & Training	The University of Manchester
NIA_NGET0163	SF_6 Management and Alternative Gases	Cardiff University, The University of Manchester, GE Grid Solutions
NIA_NGET0164	Evaluation of a Novel Variant of ACCC HTLS Conductor	Lapp Insulators, Nexans Benelux, Central Engineering & Hydraulic Services, CBS Products
NIA_NGET0165	Transformer Rating Modelling Tool Enhancement	Oxford Computer Consultants, Southampton Dielectric Consultants Ltd, The University of Southampton
NIA_NGET0166	VSC-HVDC Model Validation and Improvement (iCASE)	The University of Manchester
NIA_NGET0168	A New Independent Methodology For P&C Coordination Studies Using Real Time Digital Simulation	The University of Birmingham
NIA_NGET0176	Feasibility study on the application of advanced materials	The University of Manchester
NIA_NGET0178	Environmental Containment solutions for MIDEL 7131	Adler and Allan, Parsons Brinckerhoff
NIA_NGET0179	Travelling Wave Fault Locator Trial	
NIA_NGET0180	EPRI Research Collaboration on Electric & Magnetic Fields Health & Safety (P60) 2016	EPRI
NIA_NGET0181	Classification of Wind Exposed Overhead line Spans	Digital Engineering
NIA_NGET0182	Feasibility study on suitability of protection policy for future energy scenarios	The University of Manchester
NIA_NGET0184	Identify opportunities and developments in EMF Research (2016-2018)	Torrance
NIA_NGET0185	Investigation of transient and safety issues in gas insulated systems	Cardiff University
NIA_NGET0186	Condition Monitoring of Circuit Breakers - (iCASE)	The University of Liverpool
NIA_NGET0189	Security Assessment of Industrial Control Systems (ICS)	EPRI
NIA_NGET0190	EPRI Research Collaboration on Cyber Security 2016 (P183)	EPRI
NIA_NGET0191	EPRI Research Collaboration on Grid Planning (P40)	EPRI
NIA_NGET0194	Detailed design of 400kV 240MVA Mobile Substation Bay	ABB
NIA_NGET0195	EPRI Research Collaboration on Substations 2016 (P37)	EPRI
NIA_NGET0196	EPRI Research Collaboration on Overhead Lines 2016 (P35)	EPRI
NIA_NGET0197	Development of fittings analysis model	Amey
NIA_NGET0198	Cost effective removal of conductor crossing clearance constraints	
NIA_NGET0199	Alternatives to SF_6 for retro-filling existing equipment	The University of Manchester
NIA_NGET0200	Study into the Concept of High Impact, Low Probability Events	
NIA_NGET0201	Portable Earthing Device	Aldercote Ltd
NIA_NGET0202	Development of a Universal Bushing	Abb Group, BTRAC Ltd, John Graham
NIA_NGET0203	Novel acoustic attenuation feasibility study	WSP Environmental Ltd
NIA_NGET0204	Frequency Response Analysis for Transformer Characterisation and Objective Interpretation of Results	The University Of Manchester
NIA_NGET0206	Novel methodology for assessing environmental exposure of OHL routes	Digital Engineering
NIA_NGET0207	Development of Tools for the Assessment and Control of Impressed Voltage	P&B Weir Electrical
NIA_NGET0208	EPRI Research Collaboration on Electric & Magnetic Fields Health & Safety (P60) 2017-2021	EPRI
NIA_NGET0209	EPRI Research Collaboration on Overhead Lines (P35) 2017	EPRI
NIA_NGET0210	EPRI Research Collaboration on Substations (P37) 2017-2020	EPRI
NIA_NGET0211	Controllable Series Impedance at 275 and 400kV (CSI)	Manitoba HVDC Research Centre, Smart Wire Grid Inc
NIA_NGET0213	Condition and Climatic Environment for Power Transformers (ConCEPT)	The Watt Ltd
NIA_NGET0214	Transformer and Transformer Oil Life Optimisation and Management Through Analysis and Modelling	The University of Manchester, M&I Materials Limited, SP Power Systems Limited, SHELL Research Limited, TJ/H2b Technology Services LLC, UK Power Networks (Operations) Ltd, WEIDMANN Electrical Technology AG, SGB-SMIT Management GmbH, The Electric Power Research Institute, Inc., Cargill Incorporated Materials Limited
NIA_NGTO005	EPRI Research Collaboration on Information and Communication Technology (P161)	EPRI
NIA_NGTO007	EPRI Research Collaboration on Electric Transportation (P18)	EPRI
NIA_NGTO006	Automated identification of failures in HV assets	The University of Manchester

Our Network Innovation Competition Project

Deeside

Overview

The past 12 months have seen significant work taking place on the Deeside facility in preparation for the start of construction work on the site. The design, development and tender work for the overhead line (OHL) test area was completed, with the construction contract being awarded in June 2018. Construction will be completed by April 2019 and will be an important milestone for the facility, bringing the first energised, operational area into service so that innovation project trials can begin.

The handover of the rest of the substation, due to operational reasons, might be delayed until 2019 as opposed to 2018 as was initially projected. The impact of this risk is being managed through progress on the OHL area and considered selection of the project trials to ensure we make full use of the capabilities that are available. We are also fully developing the designs and making certain the contractual arrangements are in place so we can start work as soon as possible. The next year will see the design, development and tender activity completed for the substation section of the facility, along with the procurement of long lead time test equipment. This delay will therefore not impact the overall completion date of the project.

We have continued to review the costs and benefits. The existing control building will be refurbished to reduce expenditure. The construction of the new storage building has been put on hold until we have completed the tender process for the substation area (expected in the last quarter of this new financial year).

Business case update

The project is on track to deliver the benefits we outlined in the original bid. Presently, only our cashable benefits of innovation projects have been quantified and forecasted. Over the next reporting period we will work with other LNOs to forecast the benefits to the whole industry from the project trials.

Progress against plan

The project is on track for completion in October 2020. Some of the works and key milestones have been re-sequenced to manage uncertainties and changes in the plan.

SDRC 9.5 Completion of stage one construction works (June 2017)

The construction of the control building refurbishment has been delayed and is expected to be completed in April 2019 – a change request has been submitted for this work. This does not impact the innovation programme or potential benefits of the facility, as the OHL area and other parallel project trials can be delivered independently of this construction work. The delay will only influence the facility if it impacts the commissioning of the substation (currently expected in 2020).

SDRC 9.7 Completion of stage two construction works (May 2018)

The construction of the internal access road is also delayed. This work will be undertaken as part of the construction of the OHL area, expected to complete in April 2019. As per SDRC 9.5 (see previous), this does not impact the innovation programme or project benefits.

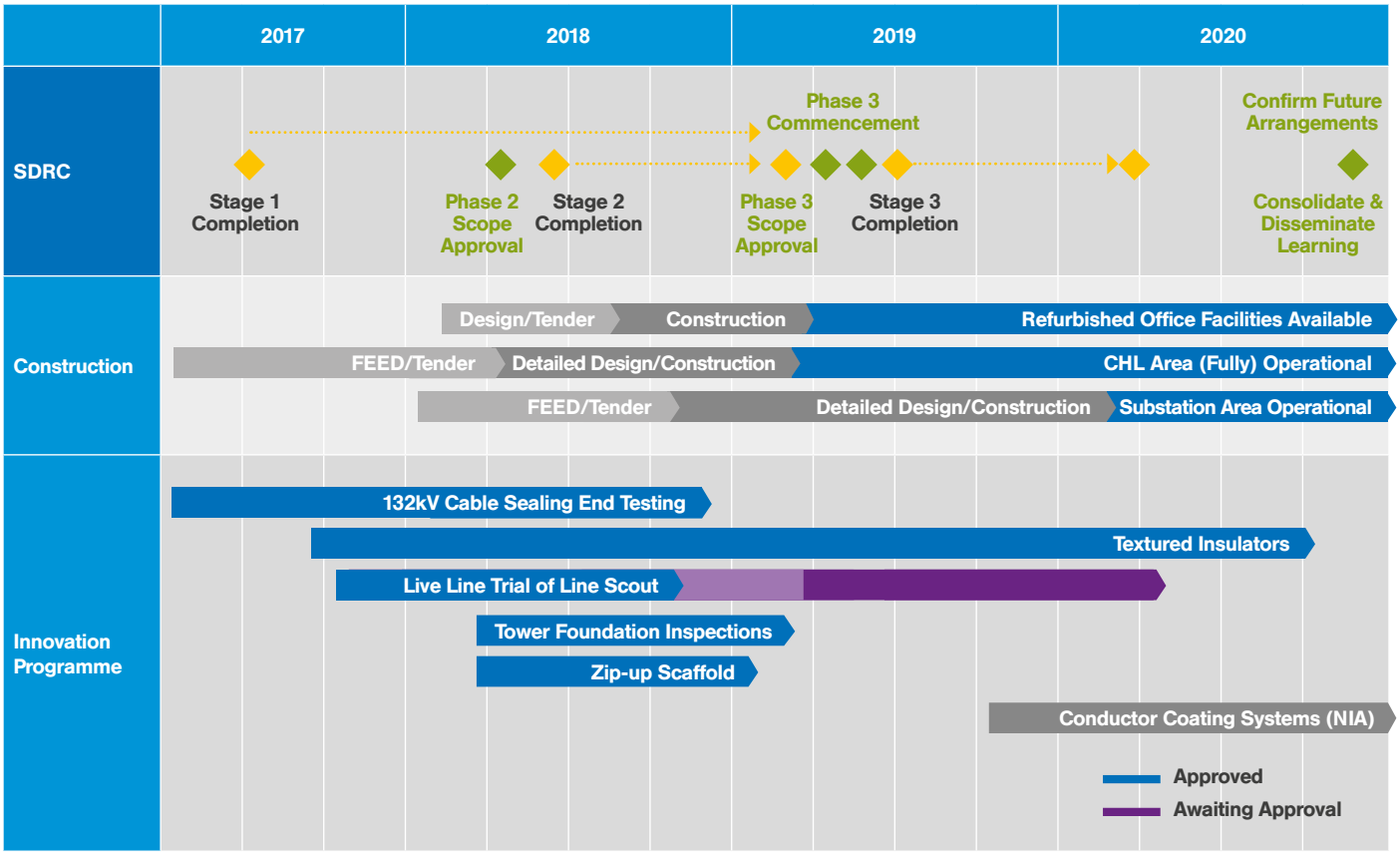
SDRC 9.6 Approval of phase two innovation programme

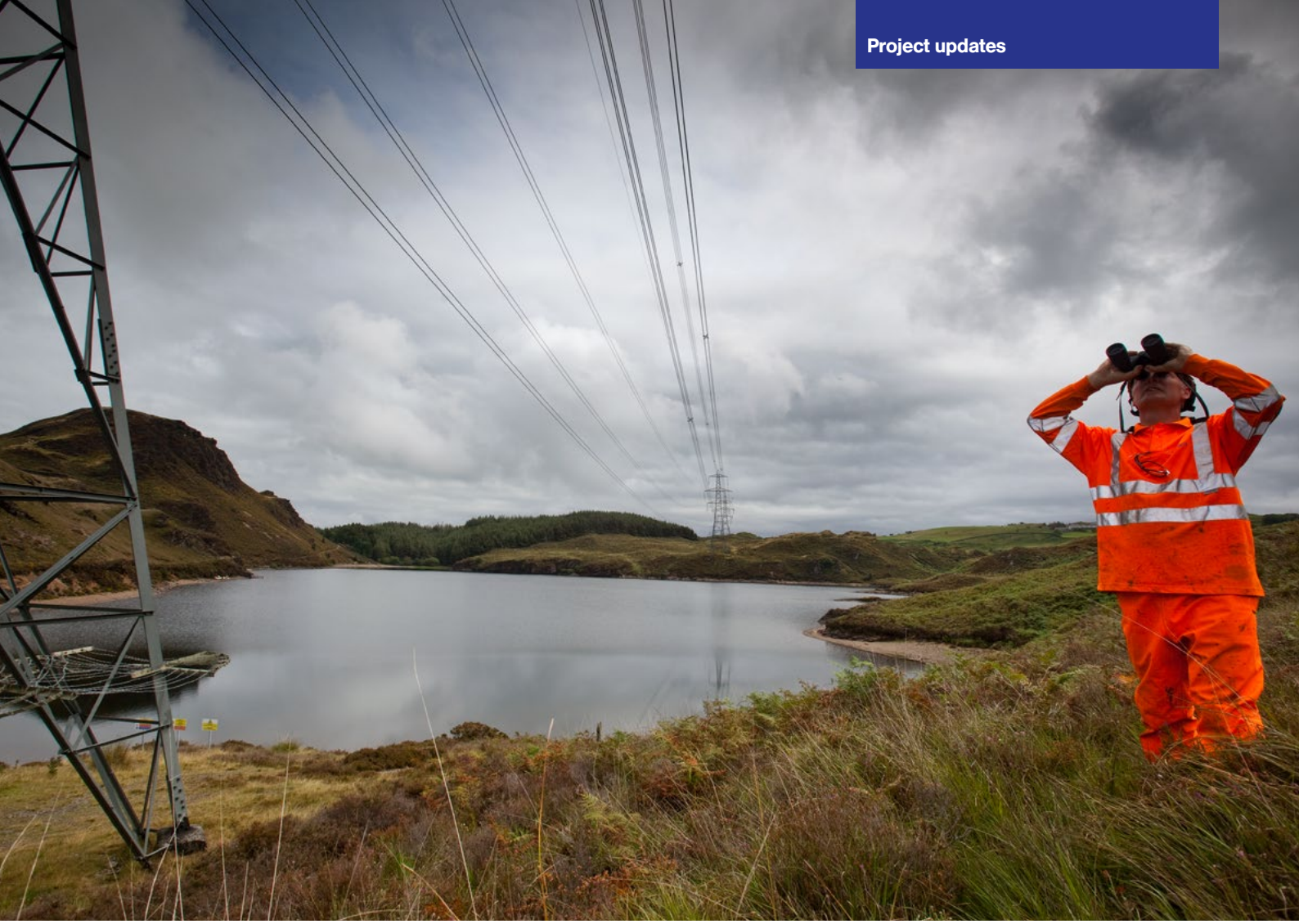
This has been delayed by two months because of lack of availability of technical advisory board members and rescheduling of the meeting from March to April 2018. Projects are now approved.

Progress against budget

The project is on track to deliver within budget. Until construction works are complete there will be delivery risks that may require use of the contingency budget. Designs for all areas of the facility have been reviewed to ensure they are efficient and to maintain the overall project forecast within budget.

Further information about the SDRC codes and status can be seen in Table 1. SDRC reference table.





Project updates

Cable sealing end

The cable sealing end project trialled a retrofit cable sealing end, developing new condition monitoring techniques for cable sealing ends, and investigating the underlying reasons behind recent failures of 132kV cable sealing ends.

The retrofit cable sealing end has gone through several design iterations to meet our challenging specifications and is now in its final design iteration.

Research into condition monitoring of cable sealing ends assured us that they are not near to failure. This meant people could work safely near our assets. As a result of this research, we now have a greater understanding of the electrical performance of silicone oil, leading to further research projects that will develop the industry's knowledge. Further testing of condition monitoring systems will begin later in 2018.

Investigations into failures of the cable sealing ends revealed several areas that the failure could be coming from. Further investigations using advanced analytics techniques looked at the information from dissolved gas analysis. This helped identify different behaviours across the types of cable sealing ends not previously known.

Working with our domestic and global partners, we are gaining a better understanding of the behaviour of silicone-oil-filled cable sealing ends.

Textured insulators

The textured insulator project developed a novel insulator not used on the network before. These new insulators are the result of a collaboration between Cardiff University, the manufacturer and us. The insulators are created by impressing a textured surface into their material. The result brings improvements in the performance of the underlying composite technology.

The textured surface makes the manufacturing difficult because of the increased complexity of the material and surface compared to previous designs. To overcome this alternative manufacturing processes have been developed so the insulators can be made to a higher standard than previous prototypes.

Test circuits, for comparing the performance of textured insulators to previous designs, are presently under construction, along with the condition monitoring systems, to measure the insulator's performance.

The first prototypes will handle 11kV and be available from October 2018. The first transmission system level insulators will be available in the middle of 2019.

Zip-up scaffold

National Grid is currently undertaking a bulk replacement of several 132kV cable sealing ends. A key factor when carrying out this type of replacement work is to have safe work areas and access to assets at an elevated height. Initial cost estimates show that scaffolding would be a major part of the replacement costs.

One way to make cost savings for this type of work is to pre-fabricate scaffolding. Removing the need for repeated redesign would help reduce outage times and reduce costs.

This project is currently in the procurement phase. We have several potential suppliers who could provide a bespoke scaffold design to support the bulk replacement of cable sealing ends. Once we have chosen a supplier, we will begin designing a new scaffold and carry out trials at the Deeside facility.

Non-invasive tower foundation inspections

Overhead line tower foundations form a critical part of the transmission infrastructure across the UK. Ensuring foundations are in good condition is essential to keeping the public safe and our infrastructure resilient.

At the moment, we inspect tower foundations by exposing a significant proportion of the foundation and carrying out a visual inspection and concrete core testing. Non-invasive inspection technologies already on the market may provide a clean and simple way to understand the condition of tower foundations, avoiding the need for digging, which would provide significant savings.

The information collected from non-invasive inspections can also be combined with other asset data, providing a better understanding of all of our tower foundations. Combining all sample data could result in a reduction in the number of invasive inspections by improving confidence in the non-invasive techniques. This would provide savings to consumers, while ensuring that the network is still safe and secure.

Table 1. SDRC reference table

Ref	Criteria	Description	Status
9.1	Formal agreement on Terms of Reference with Technical Advisory Board members.	To achieve the efficiency required to meet the project's objectives, it is essential that the other Transmission Licensees fully engage in the Technical Advisory Board. An early indication that this project will succeed will be in this Board agreeing the Terms of Reference.	Complete
9.2	Detailed design of the facility completed and approved.	The completion of both the infrastructure and technical layout designs are an important milestone on the way to delivery of the overall project as they will determine the level of testing/evaluation that can be carried out, and at which stage.	Complete
9.3	Design, develop and publish internet site.	One of the fundamental knowledge and dissemination channels for the project is the utilisation of the facility website, which will provide a secure area to share the outputs with the other Transmission Licensees.	Complete
9.4	Scope of work for the phase one innovation programme approved.	With there being a phased handover of assets, it is essential to the project's success that a detailed plan be put in place, based on the assets available during this phase. This plan will also include any relevant Network Innovation Allowance (NIA) projects that can be undertaken at this time.	Complete
9.5	Completion of stage one construction works.	The completion of the construction of the buildings and the transfer of the protection and control panels to the new control room are a key milestone to the effective functioning and monitoring of the facility, as is securing the perimeter of the overhead line enclosure.	Due: June 2017 Forecast: April 2019 Delayed due to change in control building option. Change request submitted. No impact on completion date or project benefits.
9.6	Scope of work for the phase two innovation programme approved.	The continuation of the phased handover of assets is essential to the project's success and a detailed plan is to be put in place, based on the assets available during this phase. This plan will also include any relevant NIA projects that can be undertaken at this time.	Due: March 2018 Completed: May 2018 Delayed due to TAB member availability, mitigated by early presentation of two projects in Nov 2017.
9.7	Completion of stage two construction works.	The completion of the construction of the internal access road is a key milestone to the effective functioning of the facility, as this will enable the necessary vehicles to access all areas of the facility.	Due: May 2018 Forecast: April 2019 To be delivered as part of OHL area.
9.8	Scope of work for the phase three innovation programme approved.	The continuation of the phased handover of assets is essential to the project's success and that a detailed plan is put in place, based on the assets available during this phase. This plan will also include any relevant NIA projects that can be undertaken at this time.	March 2019 On track
9.9	Commencement of phase three innovation programme.	The delivery of the innovation programme testing/evaluation is a key milestone in the project and the ability to start operations at the facility is fundamental to the measurement of its success.	April 2019 On track
9.10	Completion of stage three construction works.	The completion of the construction of the Gas Insulated Switchgear enclosure is a key milestone to the effective functioning of the facility, as this will enable the delivery of GIS and SF_6 testing/evaluation projects.	May 2019 Forecast: April 2020 Delayed by decommissioning and handover of Deeside substation.
9.11	Approval of model for enduring facility.	The Technical Advisory Board will determine, based on the flow of projects, the future of the facility.	October 2020
9.12	Project close down.	All project learning will be consolidated and disseminated appropriately.	October 2020

Table 2. Risk table

Area	Risk description	Consequence	Current			Target			Action planned (Accept, Avoid, Reduce, Transfer)
			L	I	O	L	I	O	
Delivery	Conflict of interests at TAB with regards to direction of projects.	Project stalls and delays are caused.	4	4		2	2		Adequate Terms of Reference and direction of project are agreed upfront with key stakeholders. Project Manager will need to steer the TAB back on track.
Outputs	Facility is not sustainable by the end of the NIC funding period.	Facility will close down, with land and assets sold or dismantled.	3	3		2	3		Reduce – understand stakeholder appetite from start and develop sustainable plan through funding.
Delivery	More innovation projects identified than can be planned.	May have to extend the project.	2	2		2	2		Reset the project direction, or request a project duration extension or reject additional projects.
Technical	The design of the facility does not allow value to be maximised.	Opportunity is lost as many innovations cannot be accelerated into implementation.	2	4		1	1		Detailed design of facility developed with stakeholder engagement and TAB approval required.
Finance	Estimated costs are substantially different to actual costs.	Potential project funding gap. Alternative funding required.	2	3		1	3		Reduce – ensure cost estimates are thorough, realistic and reflect full scope of work. Validate estimates based on tenders and market knowledge. Appropriate contingency to be included. Scope and capability of facility to be prioritised by TAB, as real price information is available through tender.
Delivery	Delayed installation and commissioning because of local problems. *Likely delay in handover of substation.	The project is delayed.	4	4		4	2		Reduce – careful and detailed up-front planning and liaising with the various associated schemes. Develop a dynamic innovation programme to allow modifications if required. *Further detail provided to Ofgem sponsor.
Outputs	Outputs are not disseminated appropriately to maximise benefit.	Reduction in value of investment. Lessons learnt are not shared.	2	2		1	2		Reduce – stakeholder engagement plan in place for adequate knowledge dissemination processes and methods.
Delivery	Failure to recruit essential skilled staff.	Quality of work reduces and/or delays delivery.	2	2		1	1		Key resources identified and committed. Technical experts, specialists and engineers within the business allocated time to support if/when required.
Delivery	Staff turnover.	Staff turnover causes delays to project.	3	2		2	2		Staff turnover possibility must be accepted. Engagement and standard business practices will be followed to retain staff.
Delivery	Planning permission.	Control room cannot be built and offices can undergo only minor refurbishment.	2	4		1	2		CLOSED – planning permission no longer required.
Delivery	CDM area dates extended.	Delay in building the external storage unit and innovation centre.	3	3		2	2		CLOSED – building works delayed to remove interaction.

Spending on TRL two-eight during 2017/18

£0.4m
research

£2.1m
development

£2.0m
demonstration

Technology Readiness Level (TRL)

Originally developed by NASA, the Technology Readiness Level (TRL) scale is a useful way to understand what stage any emerging technology is within the development process. The scale one-nine indicates how close a technology or new operational practice is to becoming technically and commercially viable and ready to be adopted within the business.

NIC and NIA funding are opportunities to develop innovations that may be at the relatively early stage, with TRLs between two and eight. This diversity and strong mix of projects in our portfolio reflects our staged approach to deliver continuous development, trialling and refinement of new technologies and operating procedures.

The TRLs are defined as:

Levels one and nine
Levels one ('blue sky' research) and nine (fully developed, tested and ready to be deployed) are not eligible for NIA funding.

Levels two–three
Research: activity, often with university partners, to investigate the issue based on observable facts.

Levels four–six
Development: exploring and testing potential solutions to overcome the issue.

Levels seven–eight
Demonstration: work focused on generating and testing solutions on the network, to get them to the stage where they can be used in business-as-usual.

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