Electricity Transmission Innovation Event

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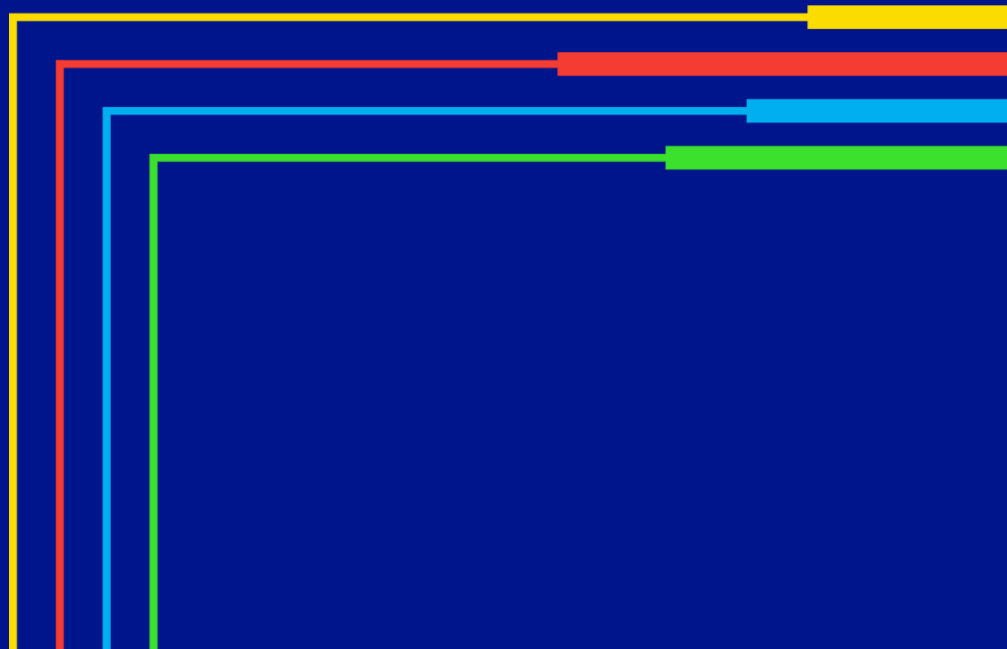
Introduction



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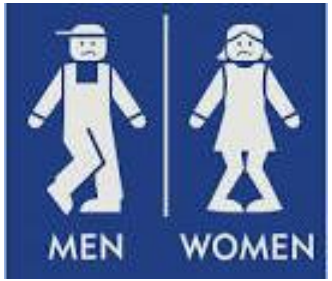
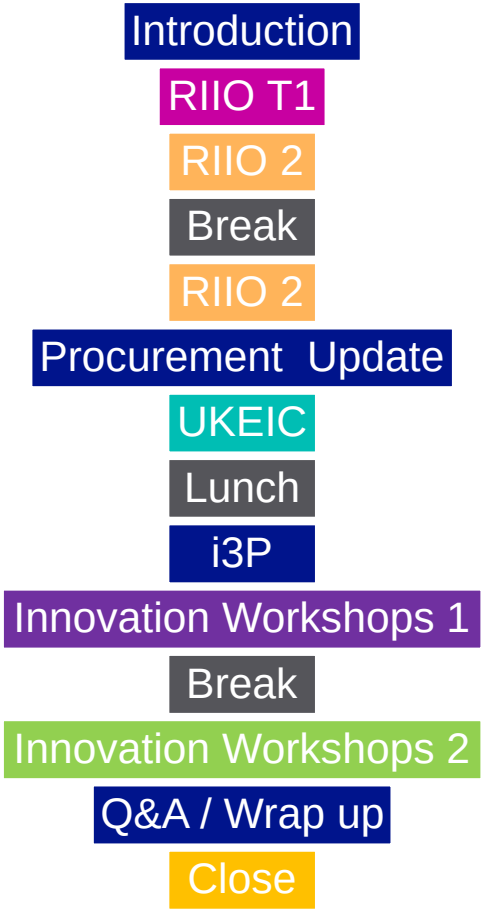
Housekeeping



Agenda


Introduction
RIIO T1
RIIO 2
Break
RIIO 2
Procurement Update
UKEIC
Lunch
i3P
Innovation Workshops 1
Break
Innovation Workshops 2
Q&A / Wrap up
Close

Innovation Workshop Logistics

Session before PM break

Purple Ticket Number	Innovation Area	Innovation Leads
1	Customer and Stakeholder	Amrit Sehmbi and Ben Kuchta
2	Protection, Automation and Control	Linwei Chen
3	Overhead Line Innovation Challenges	Ben Muncey & Anusha Arva
4	Underground Transmission – what if we couldn't replace cables	Oliver Cwikowski
5	Deeside	Thomas Charton
6	Decarbonisation and whole system design	Robin Gupta & Mingyu Sun
7	SF6 Alternatives	Gordon Wilson

Session after PM break

Green Ticket Number	Innovation Area	Innovation Leads
8	Customer and Stakeholder	Amrit Sehmbi and Ben Kuchta
9	Cyber Security	Linwei Chen
10	Overhead Line Innovation Challenges	Ben Muncey & Anusha Arva
11	Underground Transmission – what if we couldn't replace cables	Oliver Cwikowski
12	Deeside	Thomas Charton
13	Wide Area Monitoring	Robin Gupta & Mingyu Sun
14	Transformers	Gordon Wilson

Electricity
Transmission

Supporting diverse talent and creating an inclusive environment

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Purpose

An inclusive environment is one where ***everyone is welcome***, feels that they can be themselves, and the fostering of inclusion and acknowledgement of diversity is ***everyone's responsibility***. Having diverse talent and an inclusive culture brings real value to us and our organisations.

We are all at the heart of ensuring we provide the support people need.

Why is this so important ?

- **Diversity of thought drives innovation, and this is imperative to respond effectively to the drivers of change impacting all of us.**
- **To retain high performing talent, people need to feel included and that they belong**
- **A diverse and inclusive workforce will attract diverse suppliers, customers and talent**
- **People who feel included and important are more productive**
- **Ensuring everyone is treated fairly, with dignity, and has their required share of resources is simply the right thing to do.**

Inclusion isn't about equality of treatment, it is about providing equality of opportunity

Everyone benefits from the same support. They are being treated **equally**.

People are given different support to given them similar access to the view. They are being treated **equitably.**

All the people get the same access to the view without support. The cause of the inequality has been addressed and the systemic barrier **removed.**

Source: https://www2.deloitte.com/insights/us/en/deloitte-review/issue-22/diversity-and-inclusion-at-work-eight-powerful-truths.html

Am I unconsciously biased ???

Blind Orchestra Auditions

A male dominated orchestra experimented with blind auditions where musicians played behind a screen.

Initial audition results still skewed male.

Musicians were then asked to remove their shoes before they walked in, and with no sound to unconsciously bias the adjudicators, almost 50% of women made it past the first audition.

CV Study

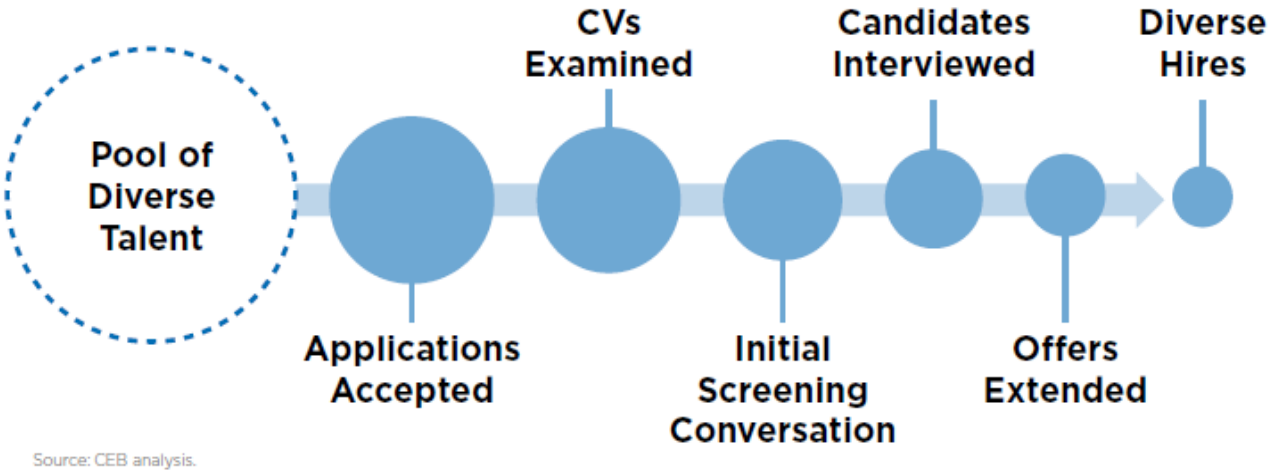
In 2010, 3000 CVs were sent out against real jobs advertised in the UK. 1000 contained a White-sounding name, 1000 an Asian-sounding name and 1000 a Black-sounding name. The CVs were otherwise identical.

The “White” CVs typically received an interview after 9 applications; the other CVs both had to wait until 16 applications for interview.

The Heidi-Howard Study (Harvard)

Students were split into 2 groups and given an identical case study about a real life successful entrepreneur. One group read about an entrepreneur called “Heidi”. The other group read about “Howard”. Both sets of students thought Heidi and Howard were equally competent, but Howard was seen as more likeable. Heidi was seen as selfish and not “the type of person you would want to hire or work for.”

Bias risk in hiring practices



Source: CEB analysis.

Eight Common Types of Bias

1. Ingroup Bias / Affinity Bias
2. Confirmation Bias
3. Halo/Horn Effect
4. Stereotyping
5. Availability Bias
6. Recency Effect
7. Loss Aversion
8. Band Wagon effect

I’m not biased !!!

Do you have implicit biases, which impact your decision making ?

- Try some of the Harvard association tests, you may be shocked by the outcome…

- **Implicit Association test – Harvard**
  https://implicit.harvard.edu/implicit/

(Choose the option to continue as a guest in bottom left corner).

Tips to mitigate unconscious bias…

- Be aware it exists but that you can control it
- Make sure you are well rested before making assessments
- Try not to ‘stretch’ the day – decisions made at the end of a long day, or days, may not be best
- Take frequent, short breaks – get some fresh air
- Keep well hydrated, but don’t overdo the caffeine
- Your brain requires fuel to function properly – sugar (such as boiled sweets) is what is needed
- Avoid snap judgements – use ‘slow’ thinking
- If possible, revisit your decisions at a later point. See if you still stand by them. Maybe even seek a second opinion

Innovation in T1

Christine Chapter
Regulatory Innovation Manager

Tom Charton
Deeside Innovation Manager

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RIIO-T1: Content

RIIO-T1: Key Innovation Funding Mechanisms

Network Innovation Allowance (NIA)	A “**use it or lose it**” annual allowance. Electricity Transmission are able to spend c. £8m annually on eligible projects.
Network Innovation Competition (NIC)	An **annual competition** for all Electricity network companies to compete for a share of £70m.

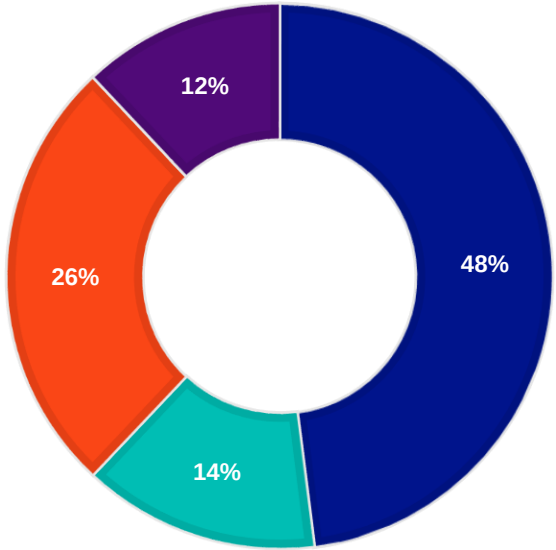
RIIO-T1: A Culture of Innovation at NGET

BRIGHT SPARKS
INNOVATION POWERED BY YOU

Encouraging our people to be **more entrepreneurial**, **open to ideas from everyone** and engaging with the **right research**, the **right infrastructure** and the **right partners**.

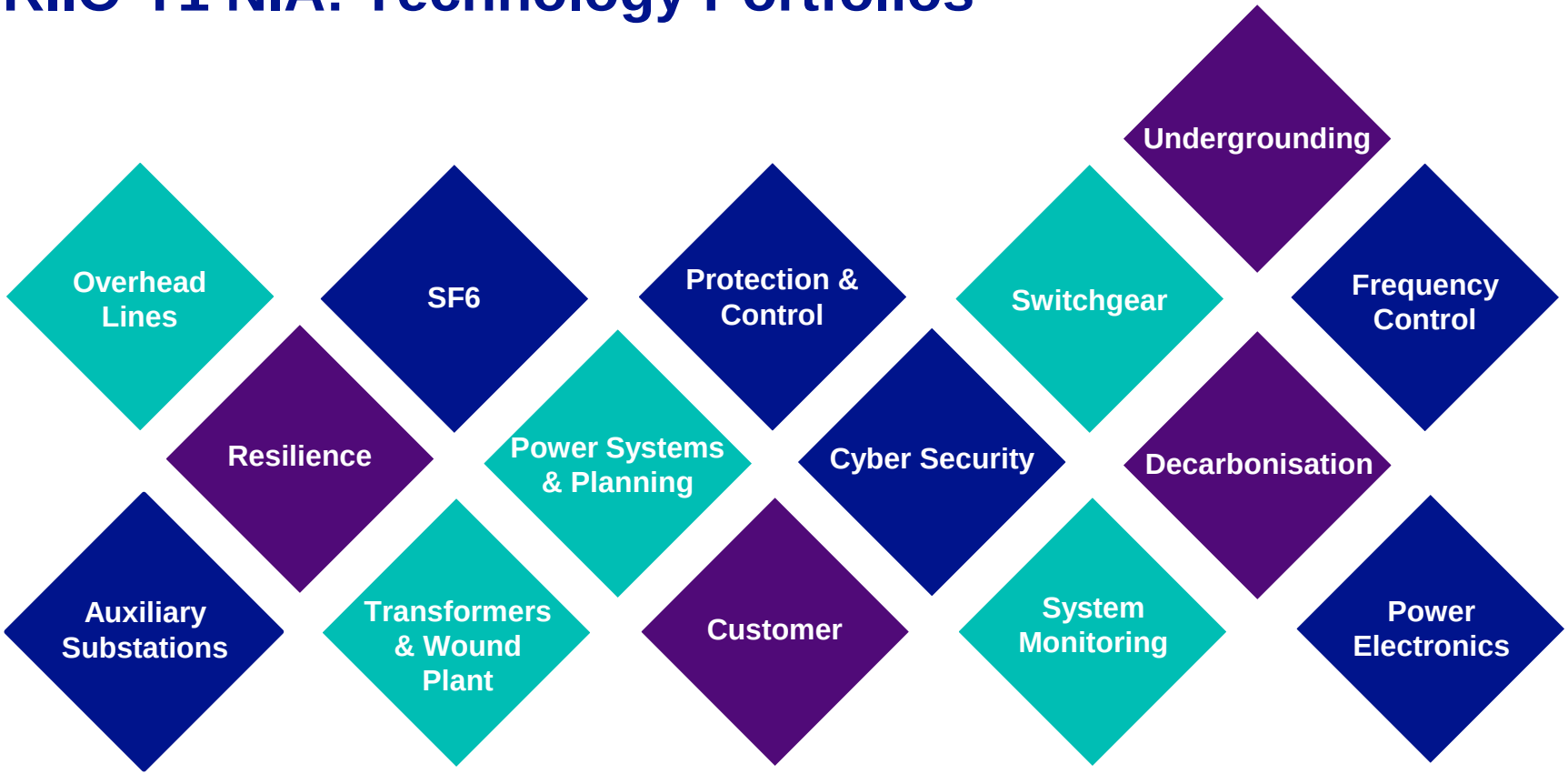
RIIO-T1 NIA: Strategic Value Areas

Managing Assets	**Maximise asset performance** at the **lowest cost** to the consumer and with the **least disruption**.
Efficient Build	**Reducing cost and time** when building new infrastructure through **trials of new products**, **adoption of more flexible equipment** and **improving network design**.
Service Delivery	Examining present and future expectations of our service to **develop what our customers and consumers need**.
Corporate Responsibility	**Improving the safety** of our practices and the **environmental and social impact** of our network.

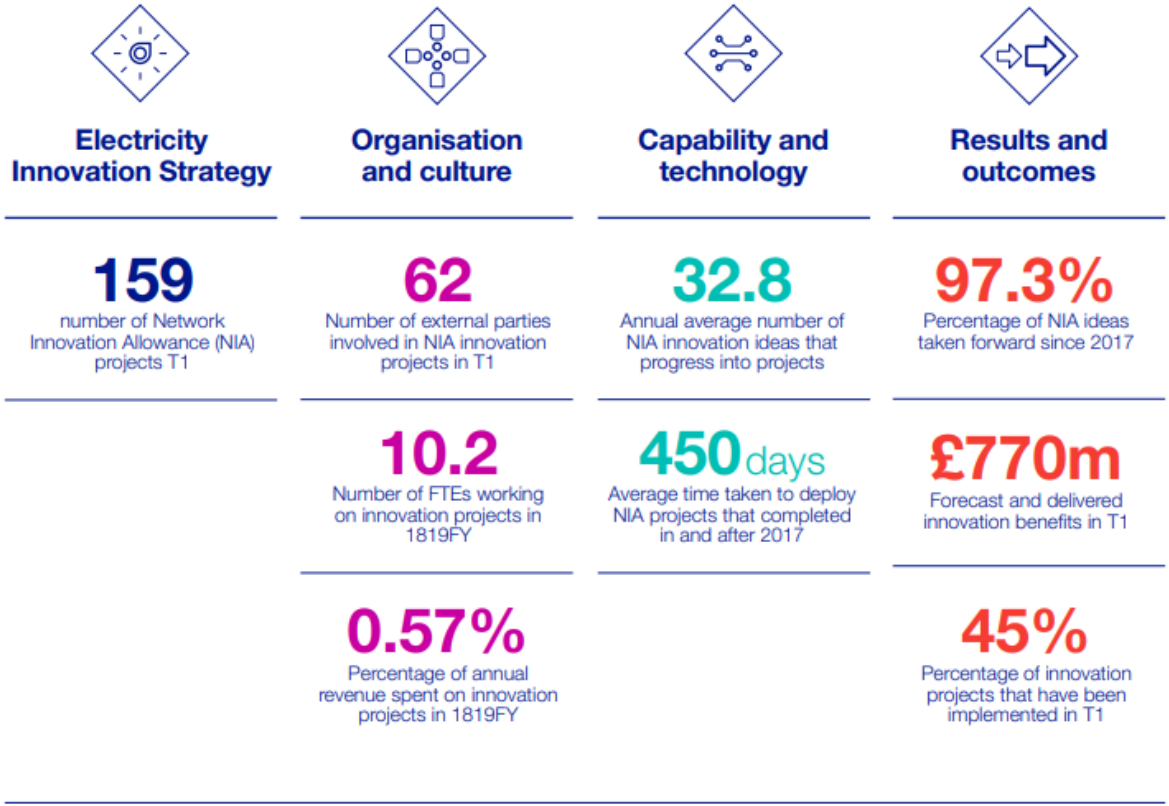


Percentage of NIA projects aligned to each strategic area

RIIO-T1 NIA: Technology Portfolios

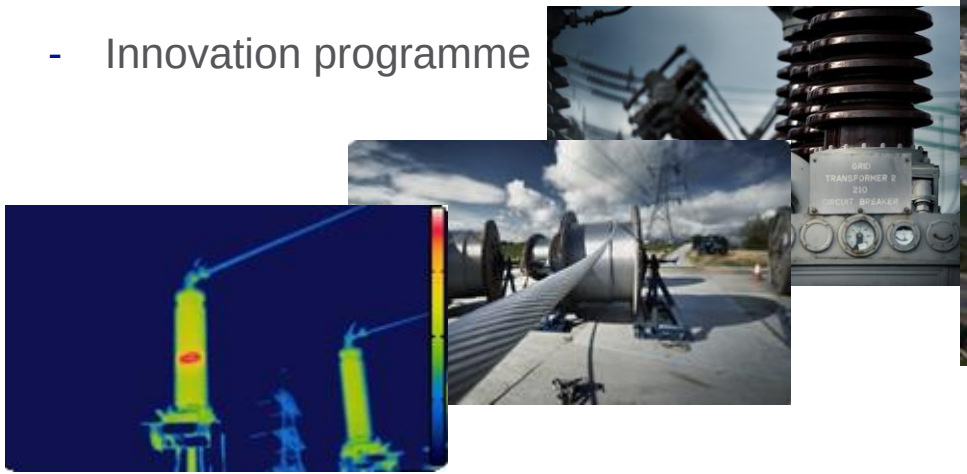


RIIO-T1 NIA: Innovation Programme in Numbers



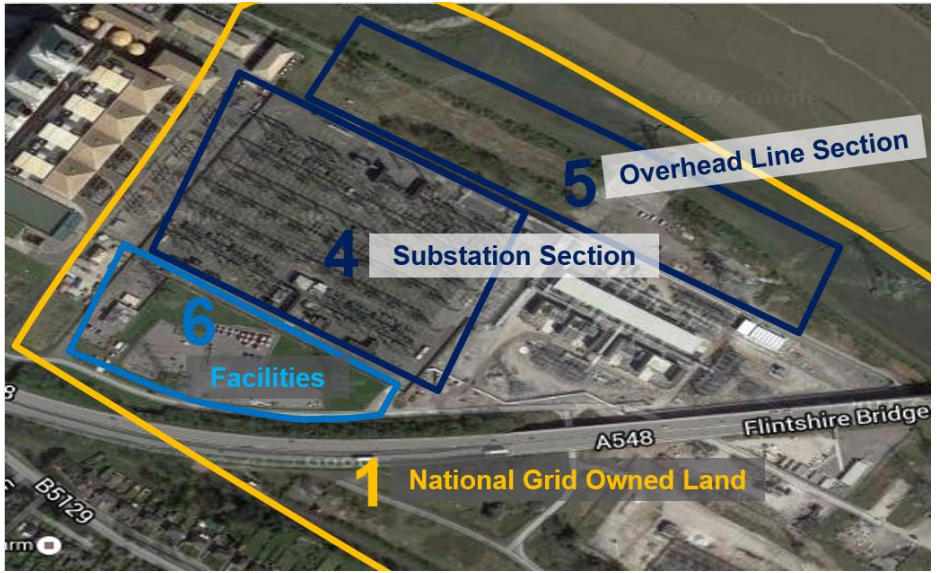
NIC – Deeside Centre for Innovation – Overview

- The Deeside Centre for Innovation – project overview
- What we have delivered in RIIO T1
  - Design and build
  - Innovation programme



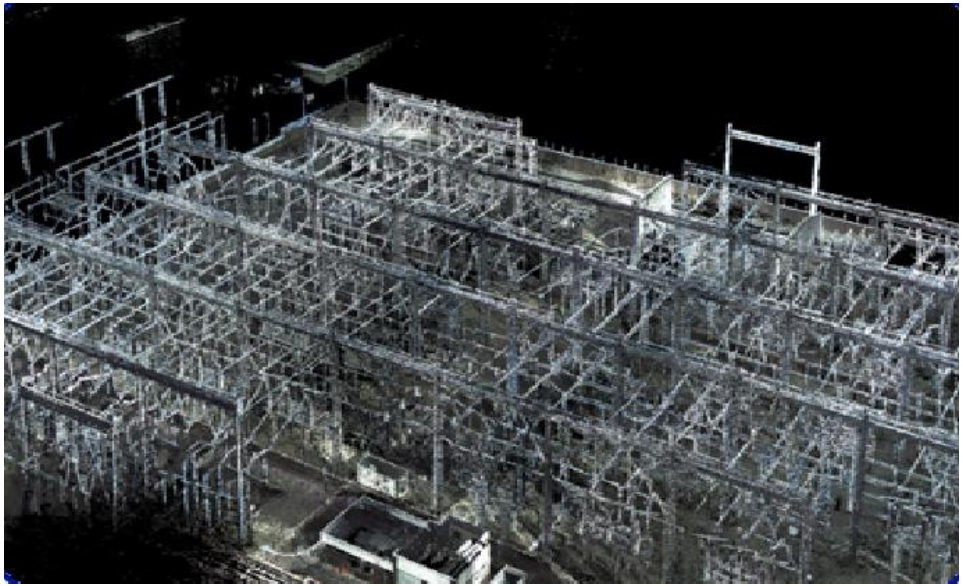
The Deeside Centre for Innovation

- Offgrid Substation Environment for the Acceleration of Innovative Technologies (OSEAIT)
- Project funded roughly 50/50 by NG and NIC
- £26m overall budget to deliver test facilities and research programme
- Conversion of a 20 bay 400kV AIS substation into an Innovation Hub and Test Centre



The Deeside Centre for Innovation – Key Objectives

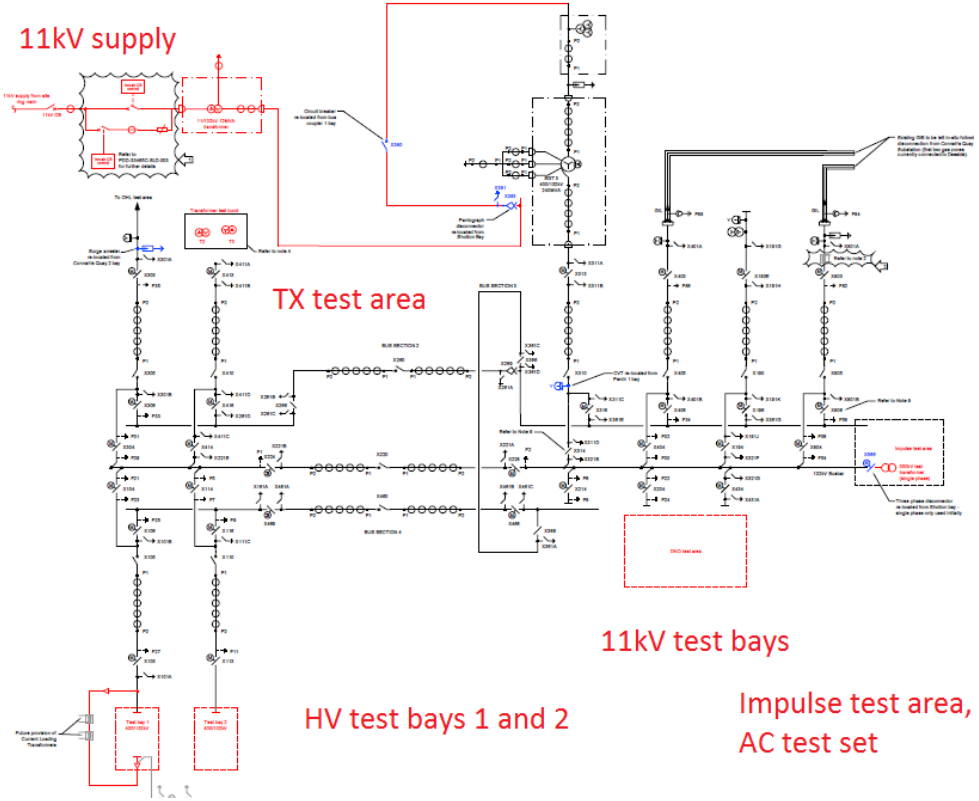
- System access 24/7
- No demand at risk
- No time constraints or project interdependencies
- Testing under system conditions
- Unique facilities for specialist HV testing
- Realistic environment for secondary equipment testing
- Maintenance, refurbishment and commissioning methods
- Life extension tests
- Trial of unproven novel equipment and procedures



The Deeside Centre for Innovation – Design and Build

Work ongoing to deliver

- Insulator test area
- Conductor test area
- HV test bays
- 11kV test area
- Transformer test bay(s)
- Impulse test area



The Deeside Centre for Innovation – Innovation Programme

Delivering benefits in T1

- Cable Sealing End failure modes and Retrofit Cable Sealing Ends
- Textured Insulators
- Non-invasive Tower Foundation Inspections
- Rapidly deployable scaffold
- Modular Bunds

Electricity Transmission

Overview of RIIO T2 and our draft business plan

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Overview of our plan – some of our key outputs

I want you to enable the ongoing transition to the future energy system	We will invest in our network to enable the decarbonisation of electricity, transport and heating in the least cost way.
I want you to make it easy for me to connect to and use the electricity network	We will connect 17.3GW of customer capacity, providing the UK with clean power, flexible storage and access to clean and cheaper power from Europe.
I want you to provide a safe and reliable network	We will invest £4,560m to renew and modernise the ageing network to keep it healthy and reliable for future generations.
I want the network to be protected from external threats	We will invest at least £620m to protect the network from cyber attacks, physical attacks and extreme weather and to be able to quickly recover the network from a shutdown.
I want you to care for the environment and communities`	Our ambitious environmental action plan includes commitments to reduce our carbon emissions by 45% (2012/13 baseline), achieve net zero emissions from construction and increase the natural capital of our land by 10%.
I want you to be innovative	We will deliver an ambitious long-term innovation programme, focused on delivering a clean energy system and lowering costs for future bill payers.
I want you to be transparent	We will report clearly what we deliver for you, with an independent stakeholder group challenging us on our clarity and performance.

We are still working on our draft plan

This is the first draft of our business plan. We are due to submit our final business plan to our regulator, Ofgem, on 9 December 2019.
We are still working on our draft business plan and are continuing to engage with our stakeholders on particular topics. We will listen to your feedback on this draft plan.
Below are some examples of the main areas we are still working on.

Consumer engagement
We are continuing our consumer engagement programme, including acceptability testing.

Energy system of the future
We are continuing to develop uncertainty measures and reflect the CCC's net zero report

The environment and communities
We need to assess the implications of electric vehicle fleet and costs for carbon offsetting

Safe and reliable network
We are continuing to engage with our stakeholders on options for reliability.

Protected from external threats
The government requirements will only become clearer later this year.

Value for money
We are still reviewing the benchmarking and efficiency evidence we have collected.

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Innovation Chapter Overview

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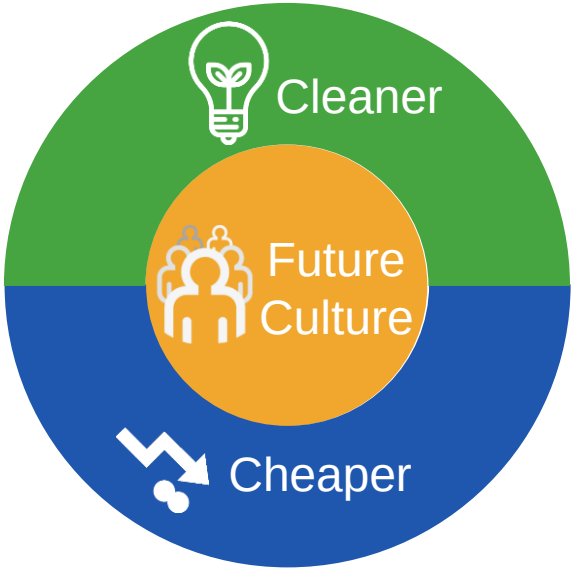
Innovation guidance for T2

Encouraging more innovation as part of BAU Activities	Network Innovation Allowance	Strategic Innovation Funding Pot
Companies to fund more innovation using totex allowance.	Opportunity for additional NIA funding if minimum Business Plan Incentive requirements are met. Focus on energy system transition or consumer vulnerability. Improvement on Reporting Required.	Funding to replace NIC and to focus on energy system transition and strategically important issues. Still under development.

Our innovation programme consists on 3 propositions



Delivering Cheaper Energy

Reducing costs to help lower consumer bills

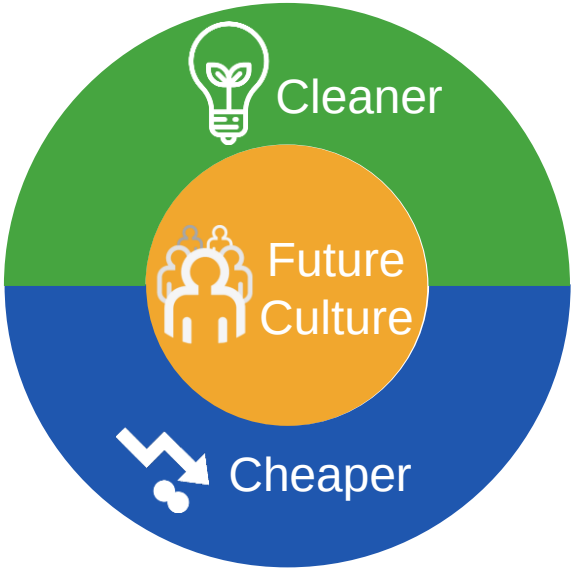
Delivering Cleaner Energy

Reducing the carbon footprint of the energy sector

Creating the Future culture

Enabling the delivery of sustainable, future innovation

Our innovation programme consists on 3 propositions



Delivering Cheaper Energy

Reducing costs to help lower consumer bills

Digitisation

The future energy system will interact, and be more dynamic than ever before. To respond to these challenges, we want to transform our business through digitalisation.

Responsive and Agile

Our customers want quicker and easier access to allow them to produce clean energy as efficiently as possible.

We want to develop tools to connect them to the network quickly and cheaply, and allow us to deliver our future work more efficiently.

Vulnerable Consumers

These innovations would allow us to reduce carbon emissions from our network and operations more cost-effectively.

Electricity Transmission

Delivering Cheaper Energy

Digitisation

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Digitisation in T1

Project examples	Spend, £k
Development of fittings analysis model	228
Transformer Rating Modelling Tool Enhancement	504
Security Assessment of Industrial Control Systems	245
Unlocking flexibility within UK Steel works	161
Computer Vision for Cable Tunnels	31
Partial discharge monitoring of DC cable	139
Wireless Sensors with Integrated Diagnostics	46
Parametric Design to automate scheme development	68
Reliability Asset Replacement Decision Support Tool	264
Resource and asset reuse toolkit	61
Digital Substation – Virtual Site Acceptance Testing	385

Asset life cycle management

Technology solutions can enable real-time, remote-control or predictive maintenance to extend the life cycle or operating efficiency of the generation, transmission or distribution of assets and infrastructure.

Grid optimization and aggregation

Grid optimization is possible through real-time load balancing, network controls and end-to-end connected markets, enabled by connected assets, machines, devices and advanced monitoring capability.

Digitisation NIA proposal for T2

Financial Year	2022	2023	2024	2025	2026	TOTAL
Funding Request (£m)	4.5	4.5	4.5	4.5	4.5	22.5

Why NIA?

Upfront cost to set-up.

Potential value generated to third parties.

What will we do?

- Investigate tools and techniques to allow the digitisation of all maintenance, with automated archiving and analysis.
- Investigate algorithms for the mixture of data with various levels of accuracies and time-frames.
- Analyse risk in real-time to maximise asset performance and value.
- Use artificial intelligence, robotics and research sensors.
- Apply techniques to our asset, financial and other data.
- Share data across the whole energy system

What will be our outcomes?

- Reduced whole system costs through the ability to collaborate with a common data platform
- Reduced costs through improved real-time asset information allowing more informed risk based decisions
- Improved analytics and intelligence in business support systems will provide information to allow lower cost decisions.
- Improved security against cyber-threats.
- Data availability for third-parties to develop new technologies and market models.

Electricity Transmission

Delivering Cheaper Energy

Responsive and Agile

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Responsive and Agile in T1

High value, long duration, hardware-based projects

Detailed design of 400 kV 240MVA Mobile Substation Bay
£1,453k

Controllable Series impedance
£958k

Responsive and Agile for Innovation NIA proposal for T2

Financial Year	2022	2023	2024	2025	2026	TOTAL
Funding Request (£m)	1.6	1.5	1.5	1.4	1.1	7.1

Why NIA?

Projects in this area take on average 3 years to develop, with several years to build. The totex incentive does not work in this case.

What will we do?

- Develop offline tools to replicate our live network, allowing us to respond to customers quicker.
- Develop new assets and installation methods that can be quickly deployed and moved around the UK to support the fast connection of customers.

What will be our outcomes?

1. Lower costs through improved optimisation of network operations
2. Quicker connection of clean-energy generation
3. Improved customer experience
4. Mobile equipment to reinforce network when required thus reducing the potential of stranded assets
5. Optimised maintenance and spare management.

Electricity Transmission

Delivering Cheaper Energy

Vulnerable Consumers

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Vulnerable Consumers NIA proposal for T2

Financial Year	2022	2023	2024	2025	2026	TOTAL
Funding Request (£m)	0.2	0.5	0.5	0.5	0.5	2.2

Why NIA?

High risk and uncertainty.

High probability of solutions at early stage increasing the cost of electricity.

What will we do?

- Engage further with stakeholders on our role
- Collaborate with parties closer to consumers (suppliers, DNOs, supply chain) to investigate and develop a roadmap.
- Explore our role in this area with stakeholders (leadership or supporting)
- Collaborate with SMEs to develop further understanding in this area of how we can support vulnerable consumers
- Investigate and develop technologies, processes and services to support vulnerable consumers

What will be our outcomes?

1. Understand the role consumers have at national level in the energy supply market.
2. Technologies, models and services to support vulnerable consumers.
3. Embedding of vulnerable consumers as part of network design and build, as well as operations, decision making

Electricity Transmission

Delivering Cleaner Energy

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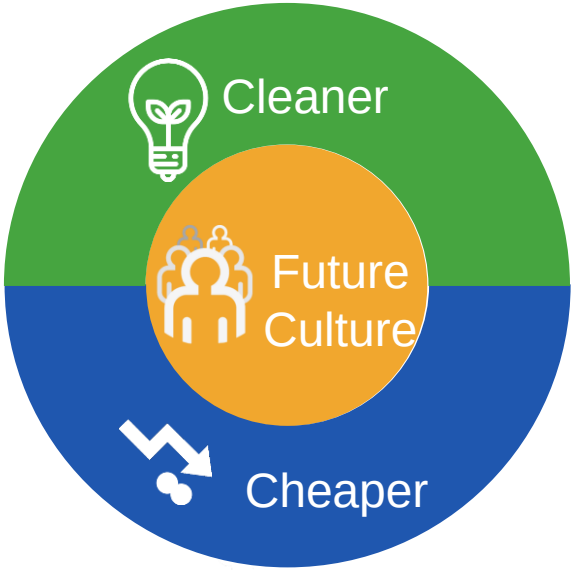
Our innovation programme consists on 3 propositions



Delivering Cleaner Energy

Reducing the carbon footprint of the energy sector

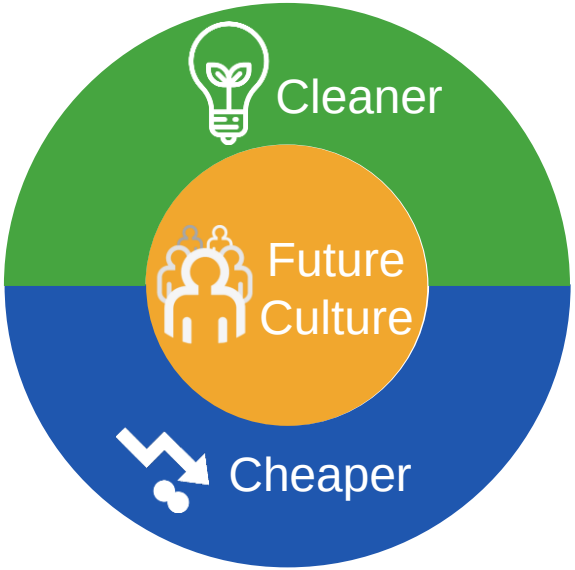
Delivering Cheaper Energy

Reducing costs to help lower consumer bills

Creating the Future culture

Enabling the delivery of sustainable, future innovation

Our innovation programme consists on 3 propositions



Delivering Cleaner Energy

Reducing the carbon footprint of the energy sector

Decarbonising Society

Despite the attempt to decarbonise, the rate of change seems to have stalled in recent years.

This is due to the technological challenges which heavy industry faces to electrify their high-energy industrial processes.

Deeside Centre for Innovation

Technologies and companies that presently do not exist will need to be created and grow.

We want to develop Deeside into a facility for utility and third-party access where organisations of all sizes can test, trial and learn in a safe and secure environment.

Reducing our Carbon Footprint

These innovations would allow us to reduce carbon emissions from our network and operations more cost-effectively.

Electricity Transmission

Delivering Cleaner Energy

Decarbonising Society

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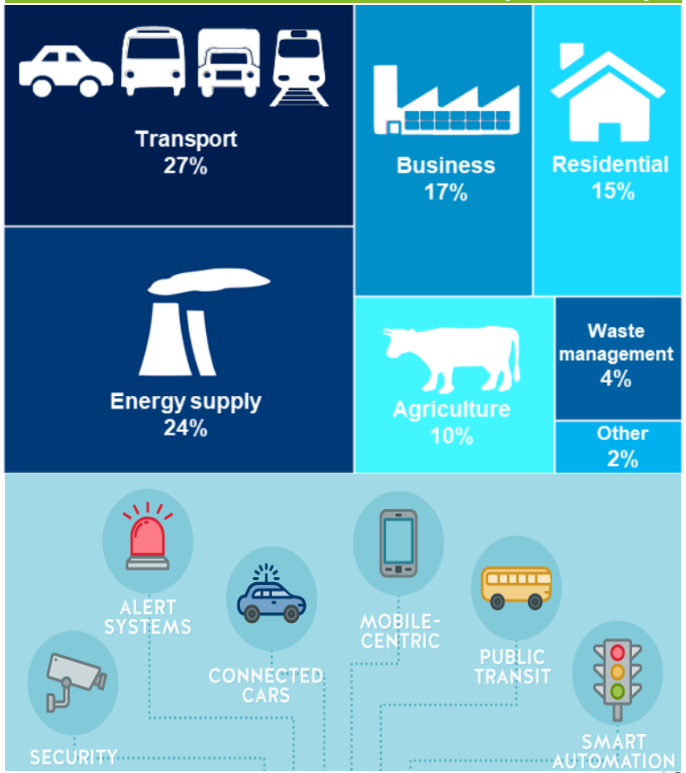
Decarbonising Society in T1

Projects	Spend, £k
Decarbonisation vision for South Wales	136
Collaboration on Electric Transportation	62 (2,756)
Electric road system for dynamic charging of vehicles	261
Feasibility study into unlocking flexibility within UK Steel works	161
Energy Highways	321
Weather analytics for the Transmission System	342
Unlocking transmission transfer capacity	140
Overload rotation to increase capacity of transmission boundaries	198
Net Zero	600

Total to Date: £2.2m (£2.8m)



Decarbonising Society, Net Zero NIA proposal for T2

Financial Year	2022	2023	2024	2025	2026	TOTAL
Funding Request (£m)	1.0	5.0	3.0	2.0	1.0	12.0

Why NIA?

Potentially no benefits.

We need to be actively engaged to reduce uncertainty and cost, as well as maximise speed of delivery.

What will we do?

- Develop technologies to support the move of transport to mobility as a service, automation and electrification whilst optimising capital investment.
- Develop and support technologies and organisations to decarbonise heat with the minimum impact to consumers.
- Develop and test technologies and market models that help decarbonise industrial processes, transport and agriculture.
- Investigate, build and prototype technologies to maximise the potential of renewable energy.

What will be our outcomes?

1. Reduction in carbon emissions from heat, transport and industry aligned with legal requirements whilst minimal reinforcement requirements.
2. Novel technologies to integrate energy vectors whilst maintaining reliability, security and affordability.
3. Open-source, bottom-up model of the energy systems to deliver resiliency and improvement in air quality at minimum capital cost.
4. New technologies to maximise electricity generation from renewables and reduction in peak generation.

Electricity Transmission

Delivering Cleaner Energy

Deeside Centre for Innovation

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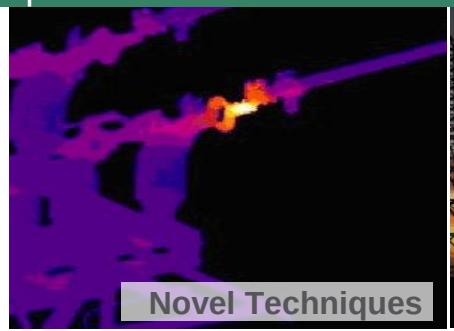
Deeside Centre for Innovation in T1

£24m NIC Project funded effectively 50/50 between NGET and consumers

The majority of our innovations and novel technologies presented by our suppliers require accelerated de-risking and more effective implementation into our business.



Objective

Develop an environment for testing innovative substation technologies. Consider:

- Assessment of interoperability and interaction of assets and technologies.
- Trial of novel maintenance/refurbishment techniques.
- Load profile cycling to assess impact and speed of ageing.
- First stage of rollout of emerging technologies and novel operating practices.

Deeside Centre for Innovation NIA proposal for T2

Financial Year	2022	2023	2024	2025	2026	TOTAL
Funding Request (£m)	2.5	5.5	11.5	6.5	1.5	27.5

Why NIA?

Support for external organisations.

High risk and uncertainty to meet ambitious targets with no clear benefit.

What will we do?

- Include all the energy vectors associated with the Net Zero ambition (eg. hydrogen, natural gas, transport, heat and new generation) with the capability to join and integrate.
- Provide the facility at cost to UK academia and SMEs to test their technologies aligned with the Government's Clean Growth Strategy through diligent governance.
- Investigate how to operationally integrate energy vectors and protection and control systems required.
- Investigate the impact of new technologies and operations on existing infrastructure.

What will be our outcomes?

1. De-risking of the testing, trialling and implementation of clean-energy, new technologies on our network.
2. Accelerated development of new, whole-energy-system technologies.
3. Delivery of the necessary technology and understanding to deliver our Net Zero 2050 ambition.

Electricity Transmission

Delivering Cleaner Energy

Reducing our Carbon Footprint

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Reducing our Carbon Footprint in T1

Projects	Spend, £k
Table interface for a SF6 mass flow top-up device	44
SF6 Capture and Leakage Repair	37
Cable oil regeneration	1,209
Alternatives to SF6 for retro-filling existing equipment	320
Long Term Stability of Alternative Gases	342
SF_6 Management and Alternative Gases	1,103
Environmental Containment solutions for Midel 7131	217
RESNET	152
Feasibility study for sustainable substation design	87
Ultrawire	118 (2,750)
Modular Bunding	TBC
Research and development of clean air solutions	TBC

Total to Date: £3.6m (£2.8m)

Reducing our Carbon Footprint NIA proposal for T2

Financial Year	2022	2023	2024	2025	2026	TOTAL
Funding Request (£m)	0.5	1.5	2.0	0.5	0.5	5.0

Why NIA?

High risk and uncertainty.

High probability of solutions at early stage increasing the cost of electricity.

What will we do?

- Investigate alternatives to SF6 that allow retrofit, and avoid purchasing new assets for the replacement
- Identify methods for reducing or eliminating cement requirements
- Investigate new technologies that do not require SF6
- Look at novel materials with a lower carbon footprint and which also help with the reduction of visual and environmental impact of our activity.
- Investigate new construction methodologies to reduce the impact of our work on the environment.

What will be our outcomes?

1. New technologies to reduce our carbon footprint from a whole-life-value perspective by 30% on top of that achieved through BaU.
2. By the end of T2, we will no longer need to purchase SF_6 technologies to deliver the best value to consumers.
3. We will have developed and tested novel materials with the potential to further reduce our carbon footprint from T2 onwards.

Break

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Electricity Transmission

Delivering the Future Culture

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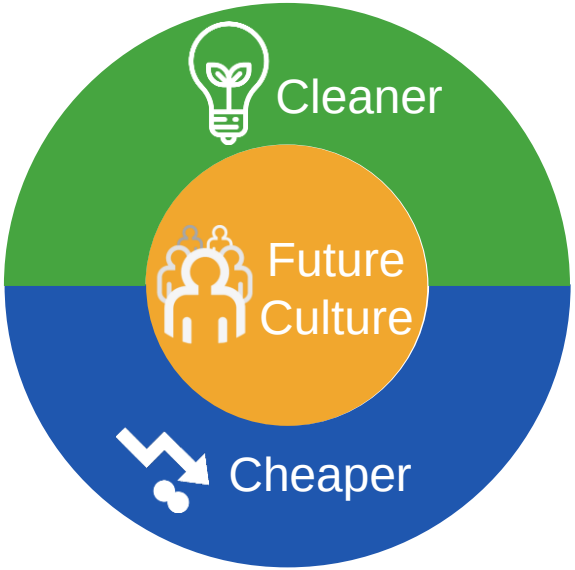
Our innovation programme consists on 3 propositions



Creating the Future

Enabling the delivery of sustainable, future innovation

Health & Safety	Self-Sustaining Innovation	Embedding sn Innovation Culture
The future energy system will interact, and be more dynamic than ever before. To respond to these challenges, we want to transform our business through digitalisation.	Our customers want quicker and easier access to allow them to produce clean energy as efficiently as possible. We want to develop tools to connect them to the network quickly and cheaply, and allow us to deliver our future work more efficiently.	These innovations would allow us to reduce carbon emissions from our network and operations more cost-effectively.

Electricity Transmission

Creating the Future

Health and Safety

nationalgrid

Health and Safety in T1

Project examples	Spend, £k
Induced voltages & currents on transmission OHLs	141
Potentials & profiles around earth electrodes	230
Rapid Deployment Ballistic Screens	192
Impact Assessment of Seismic Analysis on Electricity	220
Enhanced AC and DC safety voltage limits	312
Research on Electromagnetic and Radio Frequencies	464
Electric and Magnetic Fields Research	142
Portable earthing Device	177
Safety issues in gas insulated systems	163
Impact of high frequency earthing on the system	332
Novel acoustic attenuation feasibility study	54

Health and Safety NIA proposal for T2

Financial Year	2022	2023	2024	2025	2026	TOTAL
Funding Request (£m)	0.2	0.3	0.3	0.3	0.1	1.2

Why NIA?

No mechanisms to fund this work through BaU.

What will we do?

- Maintain research portfolio on EMF
- With new assets and ways of working coming to play as part of the decarbonisation of our network, research the current practices to investigate ways they can be improved.
- Research, investigate and develop wearable technology to be used by staff.
- Research and investigate novel technologies to increase the safety of our operations and potential impact to third parties.

What will be our outcomes?

- Safer network and operations
- Up-to-date understanding on the impact of electricity operations
- Potentially safer operations and working environment for our staff; if not, a clear articulation that modifications or additions do not reduce safety.
- Improved wellbeing

Electricity Transmission

Creating the Future

Self-sustaining Innovation

nationalgrid

Self-sustaining Innovation NIA proposal for T2

Financial Year	2022	2023	2024	2025	2026	TOTAL
Funding Request (£m)	0.8	0.8	0.6	0.5	0.4	3.1

Why NIA?

Regulated utilities depend on allowances to deliver innovation activity in future regulated periods and drive growth.

What will we do?

- We are going to modify the systems, information gathering and reporting methodology to allow levying of innovation benefits by the end of T2.
- We are going to develop the systems and processes to allow us to commercialise the intellectual property generated through our innovation programme.

What will be our outcomes?

- Reduction in costs as we develop a mechanism that will deliver long-term value from the innovation programme funded by customers.
- A mechanism that allows regulated entities with short regulatory periods to fund long-term strategic innovation that delivers value in future price controls.

Electricity Transmission

Creating the Future

Embedding an innovation culture

nationalgrid

Embedding a Culture of Innovation

Financial Year	2022	2023	2024	2025	2026	TOTAL
Funding Request (£m)	0.5	0.5	0.5	0.5	0.5	2.5

Why NIA?

High risk and uncertainty.

High probability of solutions at early stage increasing the cost of electricity.

What will we do?

- Adopt best practice principles in the area of innovation across the organisation.
- Develop a programme to drive creativity and innovation across the business, providing the training required.
- Engage, liaise and align all innovation work across utilities, government and 3rd parties.
- Outreach initiative to engage with wider stakeholders to communicate programme.

What will be our outcomes?

1. Increased speed of implementation of innovation and new technologies to accelerate value delivery.
2. Clear articulation of processes and decision making in the business and how innovation is considered.
3. Clear articulation of how innovation work is leveraged across all utilities and the wider innovation landscape maximising value to the UK.
4. Increased visibility and transparency of innovation work across a wider set of stakeholders, driving new ideas and investment into the sector.

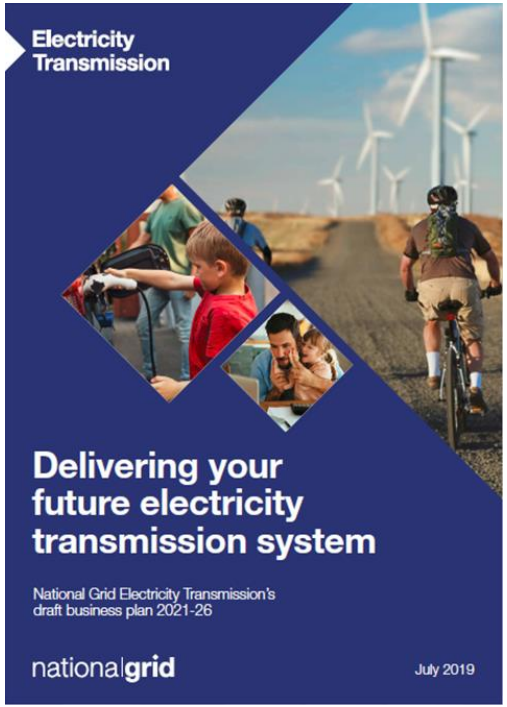
And now, time for some open conversation and any questions or comments you might have …

Electricity Transmission

Next Steps

nationalgrid

How to provide feedback on this webinar or our draft plan



We welcome your feedback on our draft plan.

- You can message us via the webex chat function now.
- You can respond via our draft business plan webpage.
- You can send your thoughts by email to: gary.stokes@nationalgrid.com
- You can write to: Gary Stokes, National Grid House, Warwick Technology Park, Gallows Hill, Warwick, CV34 6DA.

Next Steps

- **1 October 2019** - we submit a second draft plan to Ofgem's Challenge Group.

- **9 December 2019** - we submit our final business plan to Ofgem.
- **First half of 2020** - Ofgem will scrutinise our business plan and will hold public hearings on any contentious issues.
- **June 2020** – Ofgem publishes its initial findings on our plan (and other network companies)
- **November 2020** - Ofgem publishes its final findings on our plan (and other network companies)
- **1 April 2021** - the next regulatory period begins.

Innovation Procurement

Andrew Houlston
Senior Category Manager (Electricity Transmission)

nationalgrid

Contents page

Procurement Overview

nationalgrid

Current approach

- **Individual contracts in placed for specific projects**
- **Selected party based on most appropriate party to deliver the requirements based on NG's knowledge**
- **Standard set of Terms & Conditions used ensuring Intellectual Property is compliant with NIA requirements.**
- **Utilities Contract Regulations can apply for the purchase of any subsequent Good or Service**

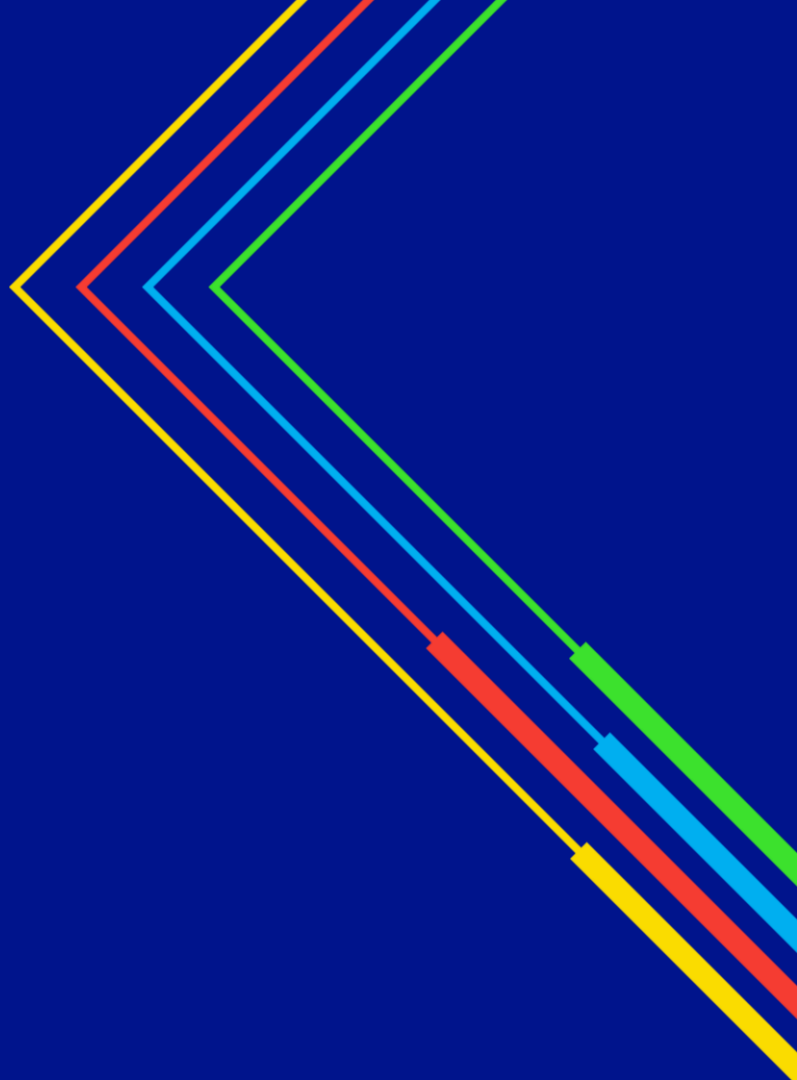
What have we been doing?

What have we been doing?

- **Work with the Innovation Team-**
  - Ensuring we understand and communicate our requirements effectively
  - Understand future requirements
  - Working with the Innovation team to give early visibility of Terms and Conditions
  - Encouraging innovation through our tender events
  - Trial with EIC

- **Way forward**
  - Develop strategy:- Embed innovation into our Category Strategies
    i. Early market engagement
    ii. Need to co-operate with potential suppliers
    iii. Proportional to requirements (OFGEM Native Competition)
    iv. **We want to talk to you about how we progress the Innovation Procurement strategy**

Q&A and Feedback



nationalgrid

Working in partnership with

nationalgrid

EIC

Collaborate to innovate

Working with SMEs in the energy sector

Matthieu Michel, Operations Director

Who are the EIC?

The EIC is <u>not-for-profit</u>

Our mission: To create an environment that allows great businesses, big and small, to openly innovate together

Our vision: To support social progress, improve the quality of people's lives and secure a safe, affordable and sustainable future.

Dementia Support

Customer Safety

Minimising Disruptions

EIC - a short history

Continued growth across industry sectors

…from electricity, to gas, to water

2008
EIC founded with electricity distribution networks

2012
Gas distribution networks join

2015
Energy Systems Catapult

2017
Ervia

2018
Water partners

2019
Additional partners including
National Grid Electricity Transmission
and
National Grid Gas Transmission

We bridge the gap between industry and innovators

Our electricity partners:

Over the past decade our global innovation community has grown to over 7000.

This growth continues to accelerate, providing you with greater access to problem solvers with cutting-edge ideas and specialist skills.

Also in partnership with:

Benefits to our partners and National Grid

Accelerating the discovery, development and deployment of innovation

- **Access to our Global Innovation Community** - Interaction with people and ideas that are otherwise difficult to reach.
- **Cross sector collaboration** - Regular opportunities to join innovation calls and projects to share costs and risks.
- **Delivery Support** - Project delivery framework for projects at all TRLs.
- **SME Insight -** Visibility of barriers to entry for innovators

What we do for SMEs

- **Access for all** - Single gateway for all innovators to access the industry.
- **Support** - We support SMEs through the collaboration process
- **Opportunities and funding**
- **Industry insight** - We have the knowledge, skills and experience to share industry insight

SME support resources include

- Intro to the Energy Sector Guide
- Podcast (EIC listening project)
- Funding Finder Tool
- Testing & Demonstration Guide

www.ukeic.com

A proven track record

More than **85%** of calls with successful outcome

Potential to deliver benefits in excess of **£40m** over the next 5 years

100+ calls for innovation launched (since 2015)

8-10 weeks from call launched to potential solutions presented

Currently **30** live projects and trials

What we do for our partners, including National Grid

ABOVE AND BEYOND

SELF HEALING ADDITIVE FOR FLUID FILLED CABLES

INNOVATION MEASUREMENT FRAMEWORK

POLLYWOOD

The EIC and National Grid Electricity transmission have partnered to launch 5 x Innovation Calls

Sep 2019

Alternative overhead line tower preparation methods

Oct 2019

Power Dense underground transmission

Plus 3 additional Innovation Calls to SMEs to be launched by March 2020

Thank you

Matthieu Michel

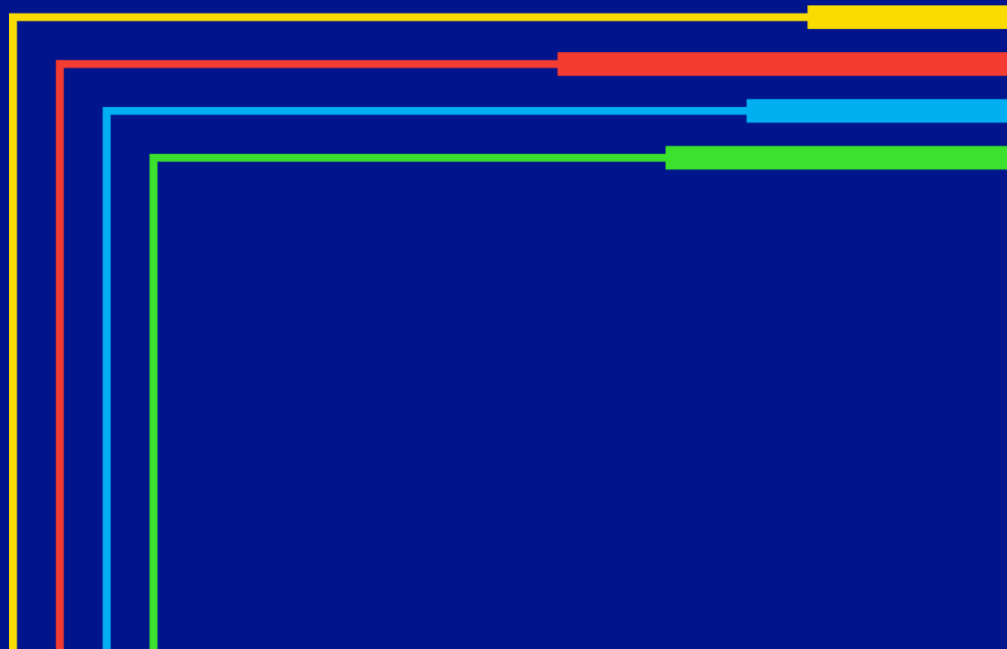
EIC
The Technology Centre
Inward Way
Ellesmere Port
Cheshire, CH65 3EN

www.ukeic.com

EIC

Collaborate to innovate

Lunch



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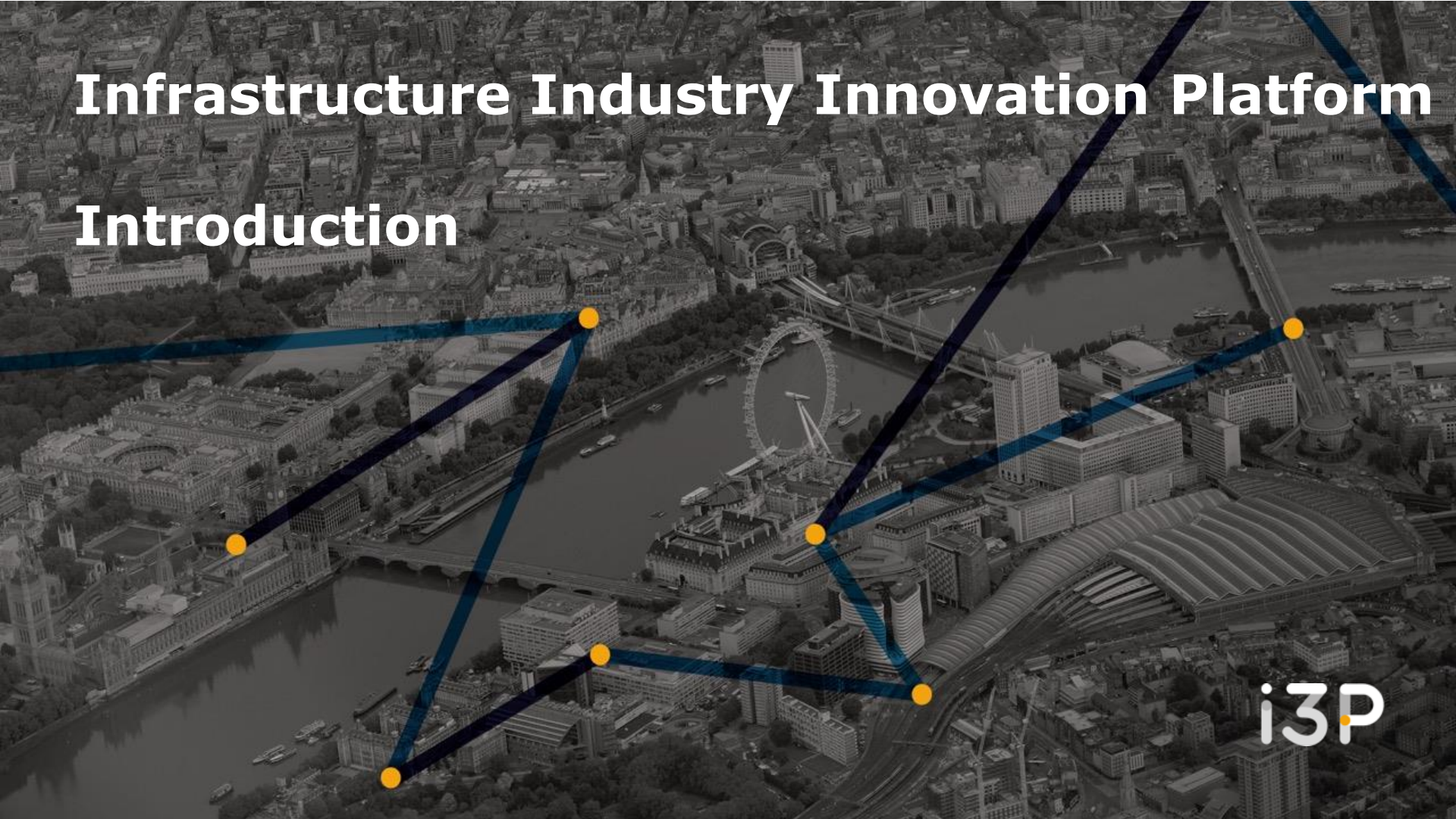
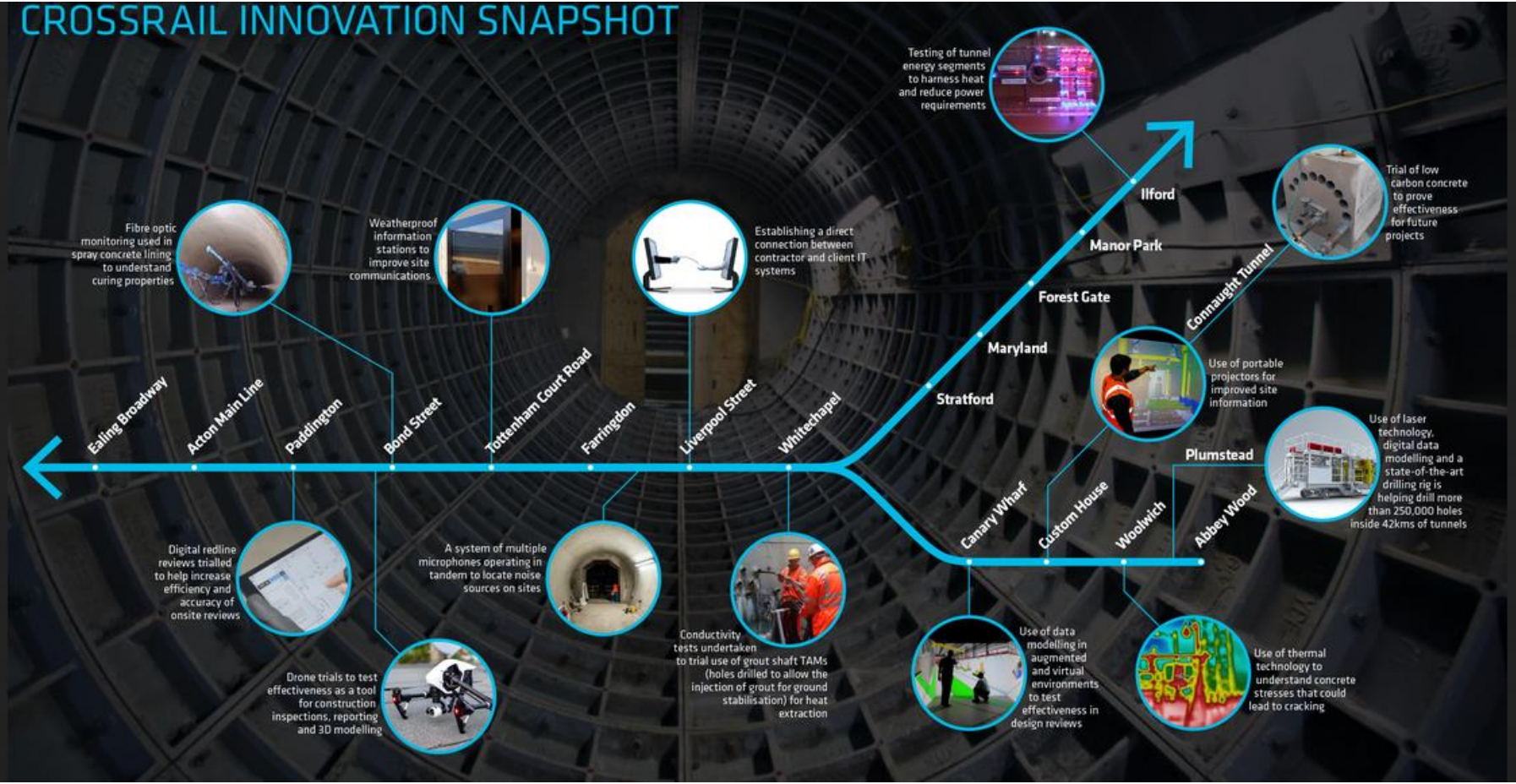
Infrastructure Industry Innovation Platform

Introduction



History

i3P History – Crossrail's Innovate 18


CROSSRAIL INNOVATION SNAPSHOT
Testing of tunnel energy segments to harness heat and reduce power requirements
Ilford
Trial of low carbon concrete to prove effectiveness for future projects
Manor Park
Connaught Tunnel
Forest Gate
Maryland
Use of portable projectors for improved site information
Stratford
Use of laser technology, digital data modelling and a state-of-the-art drilling rig is helping drill more than 250,000 holes inside 42kms of tunnels
Plumstead
Canary Wharf
Custom House
Woolwich
Abbey Wood
Fibre optic monitoring used in spray concrete lining to understand curing properties
Weatherproof information stations to improve site communications
Establishing a direct connection between contractor and client IT systems
Ealing Broadway
Acton Main Line
Paddington
Bond Street
Tottenham Court Road
Farringdon
Liverpool Street
Whitechapel
Digital redline reviews trialled to help increase efficiency and accuracy of onsite reviews
A system of multiple microphones operating in tandem to locate noise sources on sites
Drone trials to test effectiveness as a tool for construction inspections, reporting and 3D modelling
Conductivity tests undertaken to trial use of grout shaft TAMs (holes drilled to allow the injection of grout for ground stabilisation) for heat extraction
Use of data modelling in augmented and virtual environments to test effectiveness in design reviews
Use of thermal technology to understand concrete stresses that could lead to cracking

About i3P

i3P STRUCTURE AND LIST OF MEMBERS

i3P

i3P BROADER COMMUNITY

PORTAL

i3P

- KTN managed
- Innovation / idea sharing
- Apply for funding for innovation ideas
- All members have access

SECRETARIAT

Knowledge Transfer Network

- Host for Portal
- Analysis & support for Forum
- Interface with Innovate UK & other industries

STRATEGY BOARD

- Client chaired
- i3P member represented via;
  - 2 x Contractor; 1 x Design
- Government Representation
- CLC

DLG

- Client chaired
- i3P member representation
- Defines themes
- Identifies collaborative projects

WORKSTREAMS

FORUM MEMBERS

CLIENTS

love every drop anglian water
Environment Agency
Heathrow
highways england
HPC
HS2
nationalgrid
NetworkRail
Tideway

SUPPLY CHAIN

amey
ARUP
ATKINS
bam nuttall
Balfour Beatty
Bentley Advancing Infrastructure
COSTAIN
Gammon
ferrovial agroman
JACOBS
KIER
LAING O'ROURKE
mace
MORGAN SINDALL
MOTT MACDONALD
MURPHY
SKANSKA
VINCI
WSP

i3P DRIVING IMPACT

Technology Roadmap

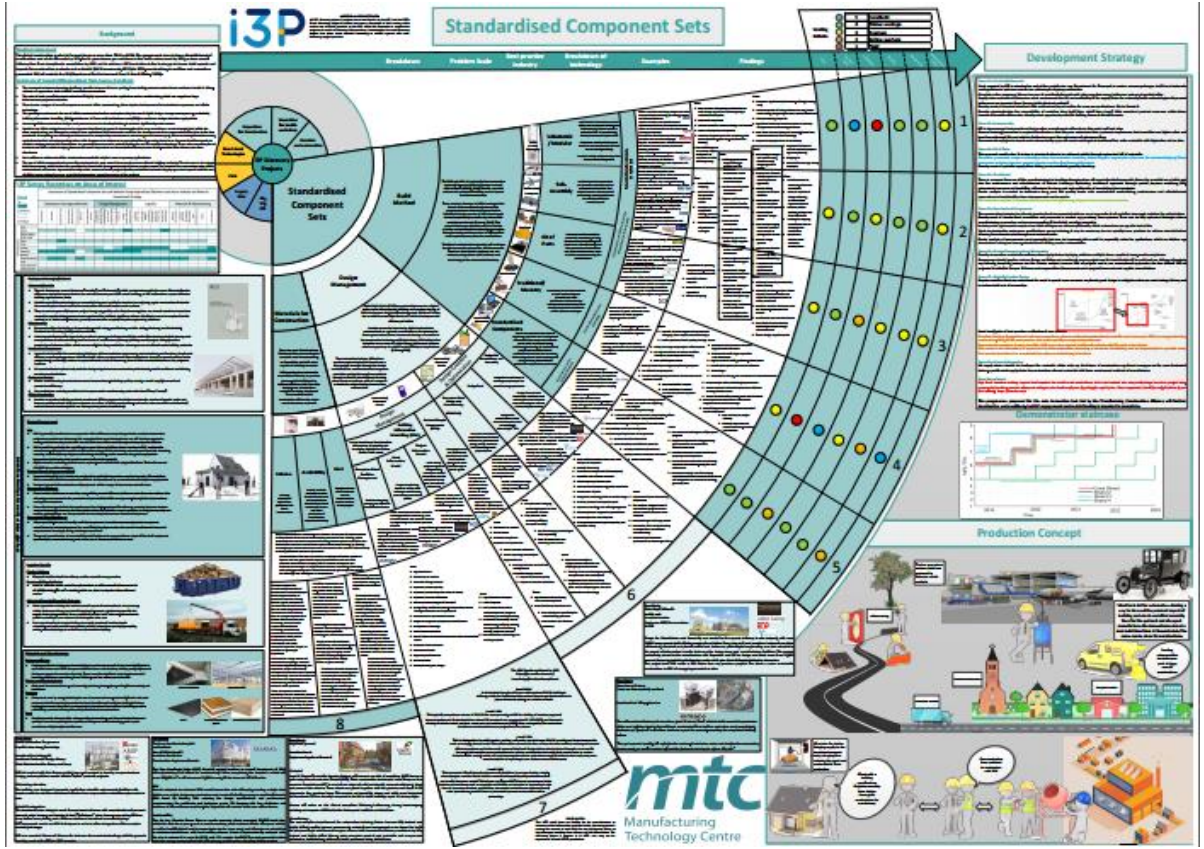
Lord Prior shares construction and infrastructure roadmap July 2017

i3P Projects

Discovery

- Wearable technology for health and wellbeing
- Standardised component sets
- Technology for skills training
- Robotics and automation
- Smart asset technologies
- Life-cycle approach to data creation
- Contractual/legal requirements for BIM
- Metrology technologies
- Legacy data conversion platforms
- Circular economy of construction materials

i3P Project Outputs (Discovery)



i3P Projects

Spark

- Computer vision technologies for creating resilient infrastructure
- Open UK: Unlocking Ground Investigation Data
- Safetibase

Impact

- Zones of Influence for large diameter shafts' A practical investigation part-funded by i3P used data created during construction of a large diameter shaft at one of Tideway's drive sites.

i3P Portal

Portal


Home
About
Contact
Innovations
News
Log in
i3P
INNOVATING THE FUTURE
helping transform ideas into opportunities
Be a part of it

i3P Shaping the Future

i3P Co-Chairs

Mark Thurston CEO HS2 and Phil Wilbraham, Expansion Programme Director, Heathrow Airport

Mark Thurston CEO HS2

Phil Wilbraham, Heathrow Airport

"There's a bigger realisation than ever before that things have to change. I3P can challenge the thinking and convene a consistent way of working together. It's the biggest thing i3P can do"

"Collaborative, industry-wide forums like i3P will enable us to unlock new efficiencies and share key learnings to drive improvements in the infrastructure sector as a whole."

Shaping the future

- ISCF £170m Transforming Construction
- Construction Sector Deal
  - *I3P was referenced as a force for change in driving collaboration, innovation and opportunity across UK infrastructure.*
- Department for Transport

Shaping the future i3P Priority Projects

- Offsite manufacturing/logistics
- Reducing the Carbon Cost of Cementitious Materials
- Decarbonising Infrastructure Through Standardising of Design
- Connected & Autonomous Plant
- Digital Verification - Automise & Digitise Construction Processes
- Optimise & Challenge Design-Design Redundancy
- Should-costing for better affordability and efficiency gains

i3P Working with SMEs

i3P WORKING WITH SMEs

IAND

Elspeth Finch MBE,
IAND

bam nuttall

Colin Evison,
Bam Nuttall

i3P INNOVATION INVESTMENT PRIORITIES REPORT

- Articulating Demand – Capable Clients;
- Addressing the Supply side – Industrialise;
- Preparing construction for a zero carbon world;
- Ensuring health, safety and well-being for all.

Shaping the future

i3P

i3P Annual report.

Launched 26th Sep

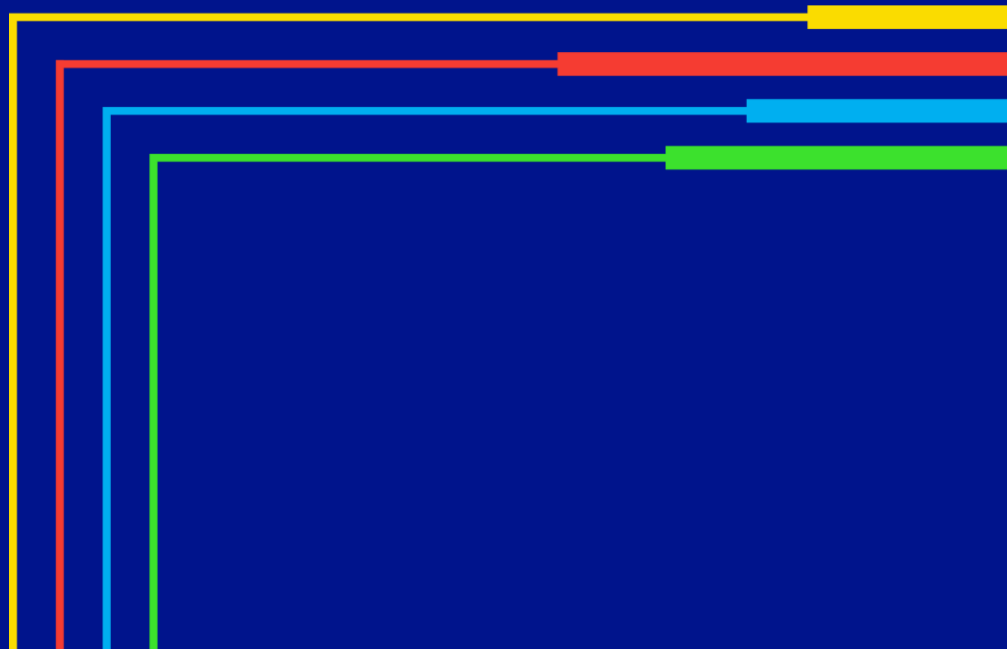
New Civil Engineer TechFest.

Thank You

Email: i3pideas@ktn-uk.org

@i3P_Ideas

Innovation Workshops



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Innovation Workshop Logistics

Session before PM break

Purple Ticket Number	Innovation Area	Innovation Leads
1	Customer and Stakeholder	Amrit Sehmbi and Ben Kuchta
2	Protection, Automation and Control	Linwei Chen
3	Overhead Line Innovation Challenges	Ben Muncey & Anusha Arva
4	Underground Transmission – what if we couldn't replace cables	Oliver Cwikowski
5	Deeside	Thomas Charton
6	Decarbonisation and whole system design	Robin Gupta & Mingyu Sun
7	SF6 Alternatives	Gordon Wilson

Session after PM break

Green Ticket Number	Innovation Area	Innovation Leads
8	Customer and Stakeholder	Amrit Sehmbi and Ben Kuchta
9	Cyber Security	Linwei Chen
10	Overhead Line Innovation Challenges	Ben Muncey & Anusha Arva
11	Underground Transmission – what if we couldn't replace cables	Oliver Cwikowski
12	Deeside	Thomas Charton
13	Wide Area Monitoring	Robin Gupta & Mingyu Sun
14	Transformers	Gordon Wilson

Customer and Stakeholders Workshop

Amrit Sehmbi, Senior Innovation Engineer and Ben Kutcha, Associate Innovation Engineer

nationalgrid

Innovation has a **huge impact** on our customers, end consumer and the **growth** of our country

Strategy

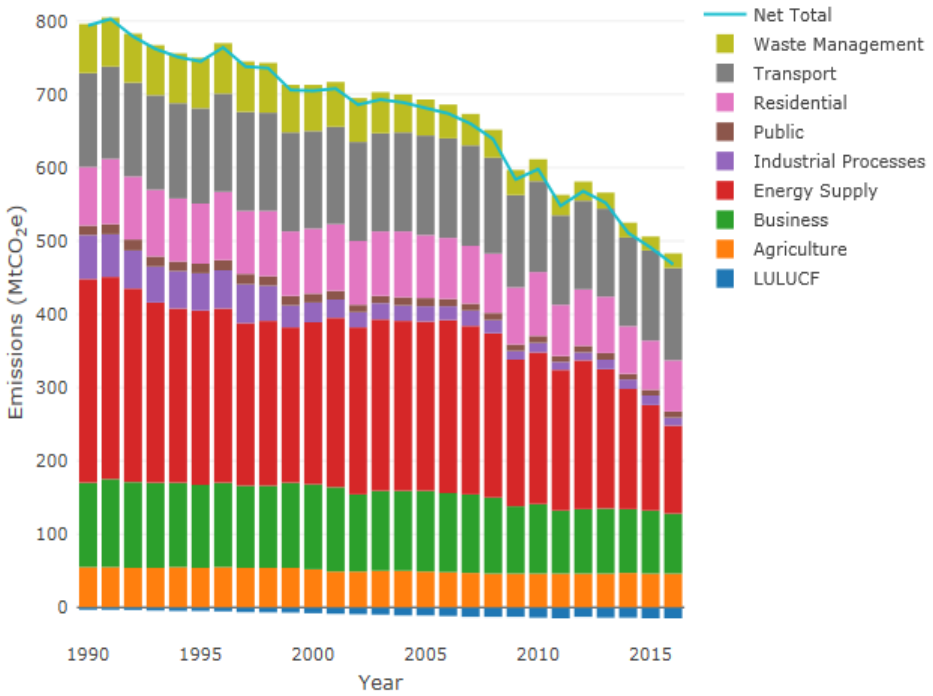
We want to be the company our customers and stakeholders turn to when solving energy challenges through innovation.

We want to……..

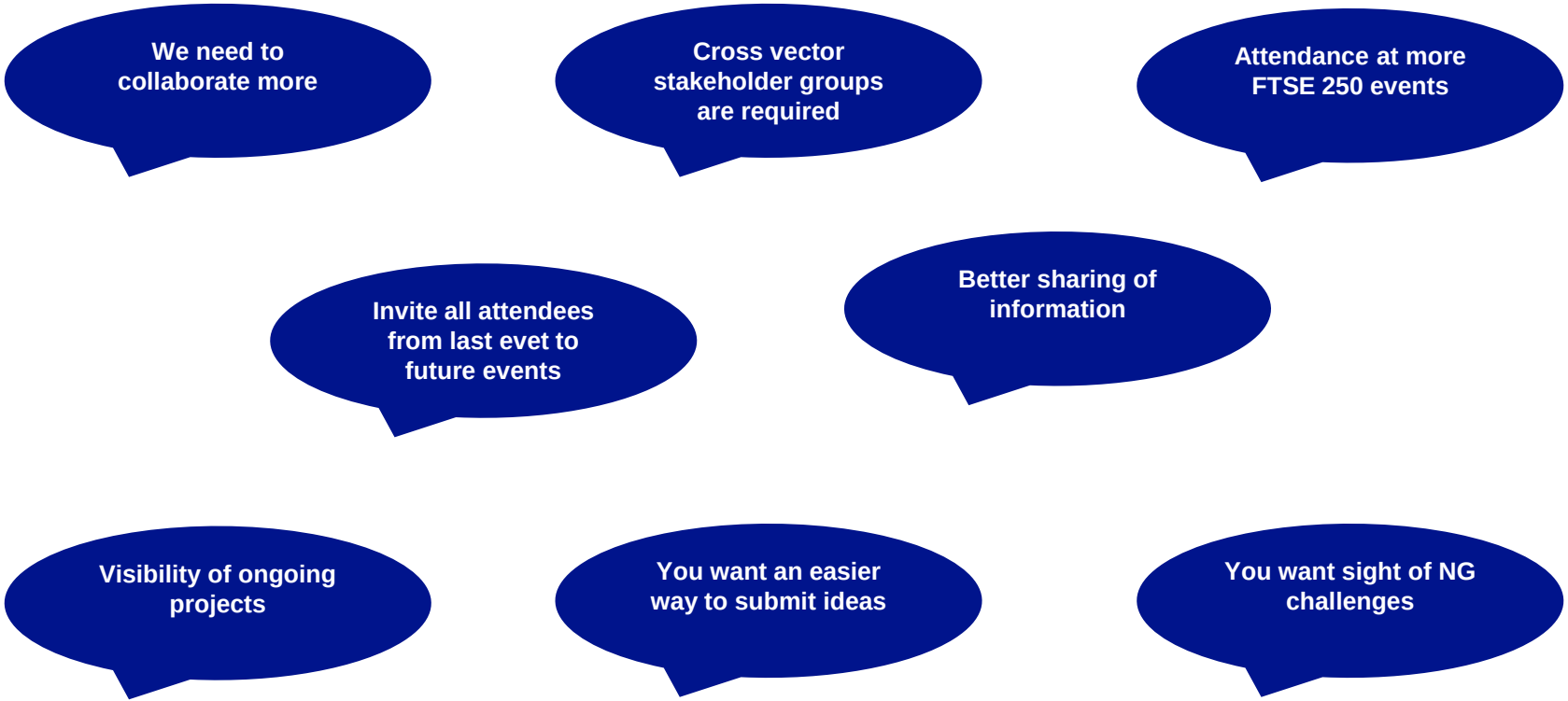
1. **Work with customers and stakeholders to provide solutions to energy challenges**
2. **Help reduce costs and drive value through innovation for all stakeholders and consumers**
3. **Engage with customers and stakeholders we have not worked with before**

Emissions by industrial processes as detailed by BEIS

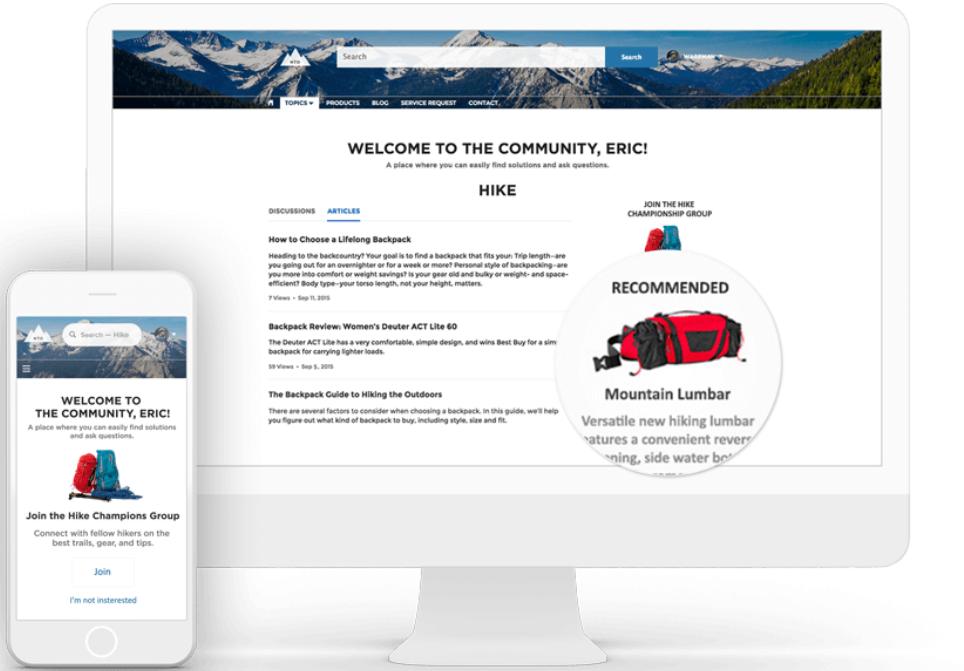
Graph shows that the focus areas to meet government targets need to be in the energy supply, transport and business sectors.



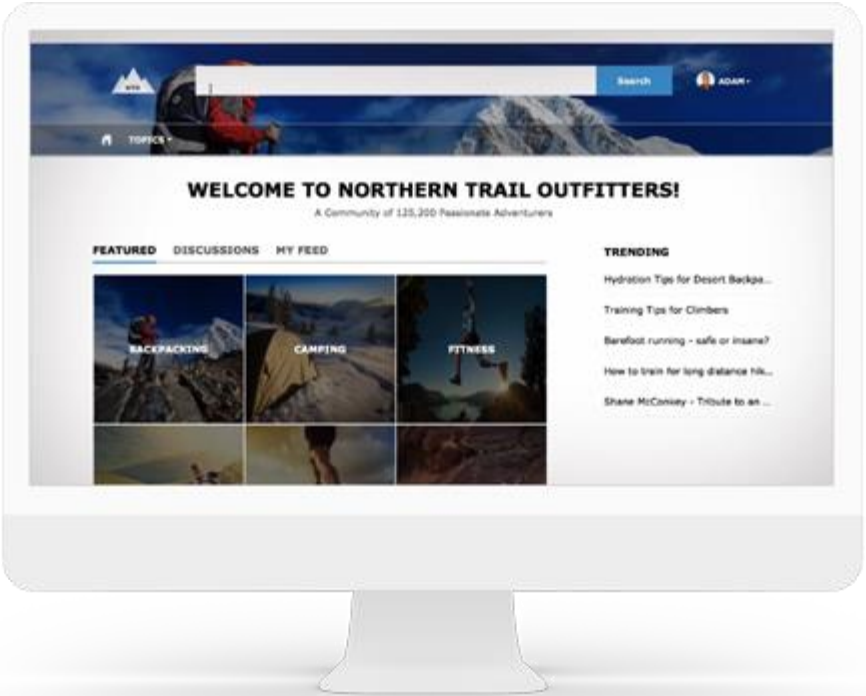
February 2019 you said…..



Customer Portal



Customer Portal



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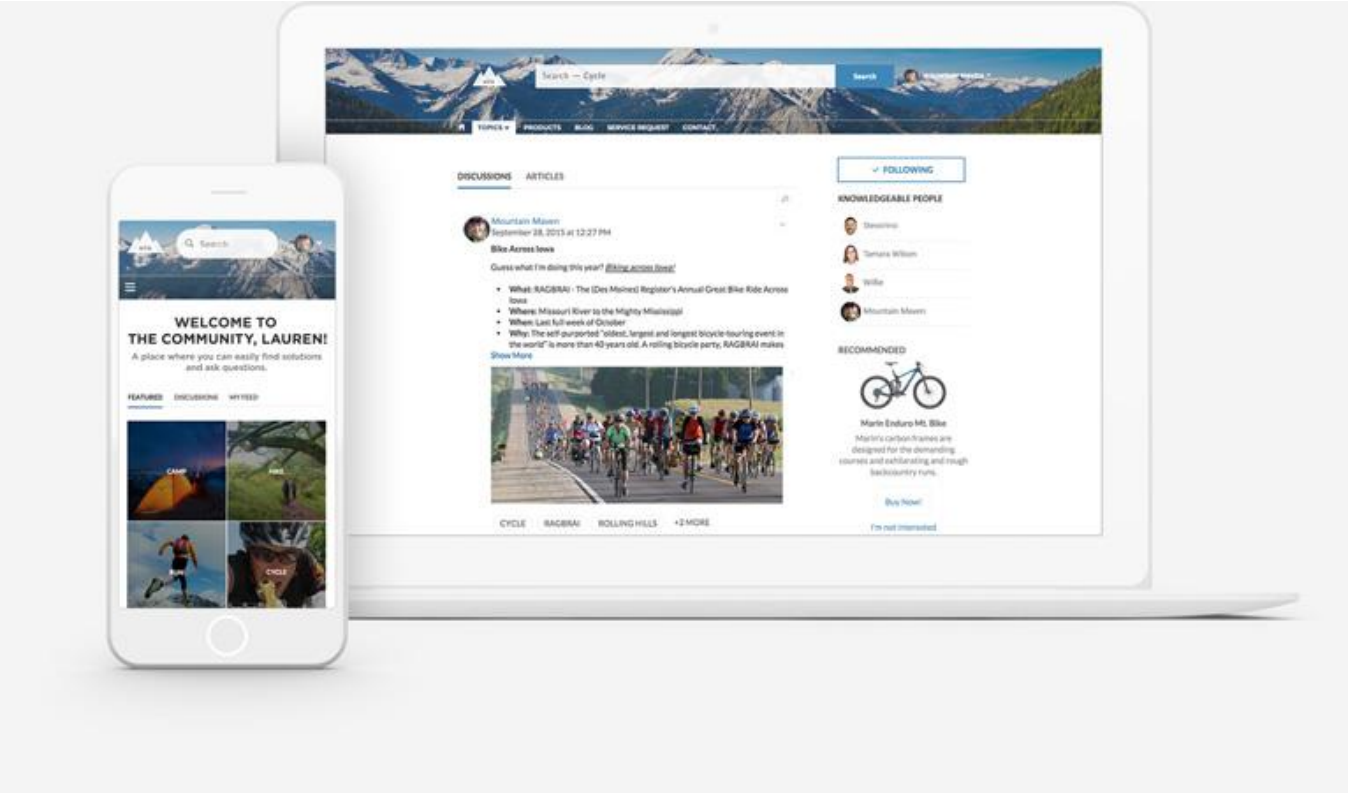
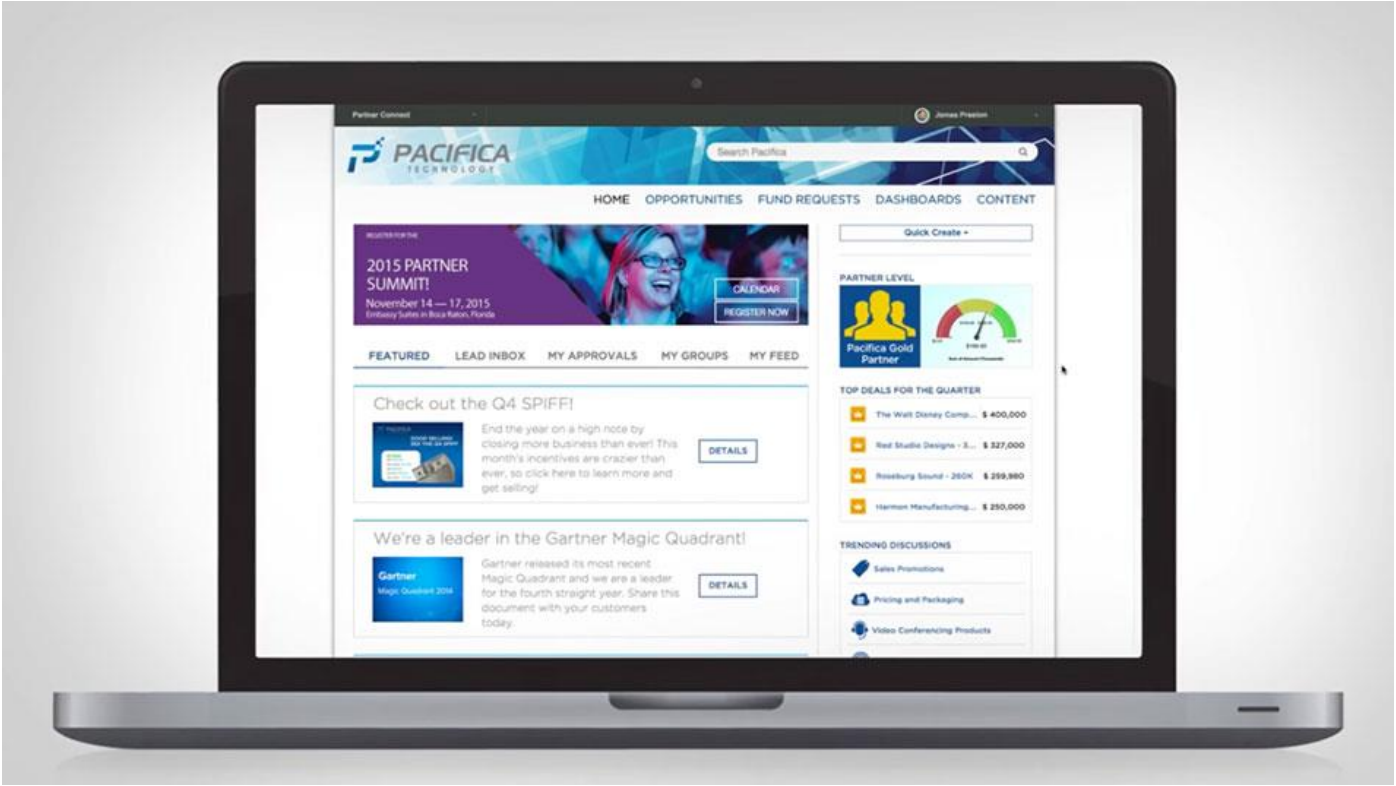
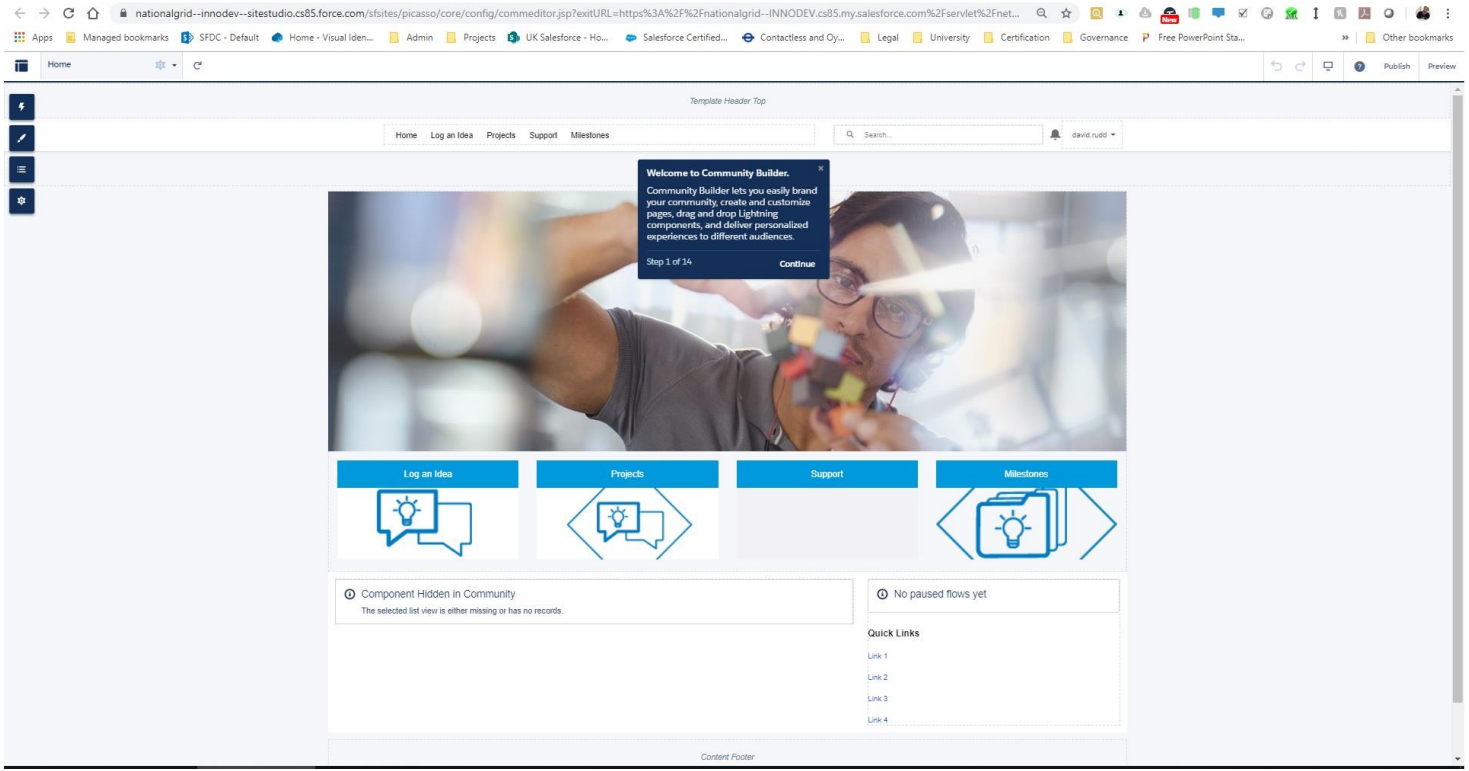


Customer Portal



Customer Portal



Discussion

1. How do you measure success?

2. How can we better understand customer/external problems?

3. What does a good outcome look like?

4. Methods of collaboration

5. What else would you like to see on the website/portal?

Innovation Insights

Collecting consumer insights relating to macro trends that will add value to our commercial and technological future strategies.

- Understand the attitudes and behaviours of the end consumer to help understand what drives the need for technological innovation and identify areas of opportunity
- Understand the changing societal and technological trends that influence National Grid's innovation programme both now and in the future
- Track trends in consumer behaviour to help identify innovation opportunities
- Provide examples of industry reactions to consumer attitudes and requirements that will also act as inspiration for National Grid's innovation programme

Industry focus areas:

- Energy
- Transport
- Technology
- Sustainability
- Data analytics and artificial intelligence

The 5 Macro Trends

DEMOGRAPHICS

Fewer 2.4 families, more singles, multi-generational families and working and lone seniors.

URBANISATION

Faster, transient lifestyles and diminishing space. More commuting and independent working.

HEALTH

Pollution, obesity, sedentary lifestyles and rising levels of stress and anxiety.

RESOURCES

Growing demand for sustainable water, ingredient, energy and packaging solutions.

CONNECTIVITY

Automated solutions delivering, speed and personalised analysis.

ENERGY | TRANSPORT | TECHNOLOGY | SUSTAINABILITY | AI & DATA

Environment

OBSERVATIONS	CONSIDERATIONS IN INNOVATION
• UK consumers most likely to classify themselves as 'compromisers' when it comes to environmental commitment. • Time and money expenses remain key barriers to more consistent commitment.	• Focus innovation on areas that make it simple and easy for consumer to adopt. Changes in the home or as part of a daily routine would be more accepted to begin with. • The more committed consumers are to reducing their impact on the environment, the more accepting they are of 'out there' concepts. Use them as your primary target to establish 'mainstream' status when larger majorities are more comfortable adopting new concepts.
• Consumers cite issues that are most visible (in the media and physically) as their biggest concerns • Energy issues aren't as visible as plastic waste but changes in reported behaviour suggest consumers taking action to reduce their impact on the environment • The UK Government and Energy Suppliers are cited as being accountable for energy efficient innovations.	• National Grid's innovation can influence and facilitate other organisations • There is a lack of awareness in what's being done behind the scenes, can National Grid and their commitment to Decarbonising the Nation become more visible. • Investing in marketing & communications that help consumers to understand the issues around energy and help to drive changes in behaviour. • Partnering with charities and NGOs that are perceived as being the most active in limiting our impact.
• Whilst aesthetics of energy infrastructure not seen as a huge concern, this will increase as assets become more common. • Community project concepts are already widely accepted.	• Despite consumers saying these new innovations are not imposing on the landscape, this is likely because they're not yet that prominent. • Assets for new innovations should integrate and naturally complement the surrounding landscapes as much as possible top prevent negative perceptions from suppressing uptake. • Consumer report a mind-set that seems grounded in 'power in numbers'. Working together to reduce 'our' impact may be easier to implement than changes on an individual scale.

Transport

OBSERVATIONS	INNOVATION OPPORTUNITIES

• Hybrid cars remain more popular than electric alternatives
• There is a perceived lack of charging points for electric cars
• Electric cars are seen as significantly more expensive than regular ones
	• National Grid could encourage the installation of electric car chargers across the UK by:
	  • Supporting the rollout of a (fast) charging network
	  • Helping to standardize charging points
	  • Creating a "National Grid" verification for car chargers, to help consumers understand and trust charging devices
	• National Grid could start collaborating with V2G charging suppliers, which can help regulate the grid and give financial benefits to EV owners.

• Micro-mobility is taking off, especially in cities • Dockless ridesharing services are causing significant problems	• National Grid could help build a network of mixed docking and charging stations to help regulate ridesharing services while also increasing its energy storage buffer.

• Consumers with cars are less likely to take public transport
• A car is seen as a necessity, with most consumers agreeing that it provides freedom
• Consumers aren't clear on the science behind emissions and many don't believe electric cars are greener
	• By working on green public transport projects using electric or hydrogen power National Grid could:
	  • Increase the appeal of public transport for environmentally conscious consumers
	  • Call attention to the feasibility and safety of emerging technologies
	  • Call attention to the reduced emissions and reduced environmental impact of these new technologies

Energy and Innovations

OBSERVATIONS	CONSIDERATIONS IN INNOVATION
• Consumers show significant interest in green energy, with a third of people using a green electricity and/or gas tariff • Despite good insight into energy bills and tariffs, not everyone knows how their electricity and/or gas is generated • Demand for green gas seems to outpace supply	• National Grid could start driving increased transparency regarding green energy tariffs, making information available on how electricity and gas is produced and how it is delivered to consumers • An example would be to create a National Grid verification that indicates what percentage of energy from a supplier/tariff is renewable • Support new and existing suppliers of biomethane by providing infrastructure to deliver to the grid
• Consumers are more likely to report having a fixed rate tariff, indicating limited influence of electricity pricing on consumer behaviour	• Increasing the market share of variable tariffs could contribute to a more balanced grid • Research still needs to be done on whether consumers change their behaviour based on energy prices
• Consumers are both financially and environmentally incentivised to save electricity, gas, and water • They single out the use of gas as causing the most emissions in the home • Around a third of consumers says they are actively trying to reduce their usage (with more affluent consumers being more engaged)	• There is potential to motivate consumers to make investments to improve the energy-efficiency of their home, by highlighting the return on investment and supporting the installation of better insulation and/or energy efficient heat pumps • By collaborating on the construction of new developments, National Grid could have significant influence on the energy efficiency of new homes, while experimenting with new innovations such as ground source heat pumps, distributed electricity storage, hydrogen gas, etc. • National Grid could support the development of crowdfunded renewable energy projects by getting involved to win consumers' trust

Electricity Transmission

OHL Innovation Workshop

Ben Muncey, Senior Innovation Engineer and
Anusha Arva, Innovation Engineer

nationalgrid

OHL Innovation Workshop: Asset Health

OHL Challenge Areas

- Maximise the life of our overhead line assets (asset health)
- Ensure our overhead line assets are utilised to their capacity (asset ratings)
- Reduce the time or cost of installing and maintaining overhead line infrastructure
- Improve our operations in line with company values and consumer expectations

How do we intend to address them?

- *Considering specifically asset health;*
- 55% of capex investment for OHL assets in RIIO-2 relates to conductor replacement.
- Deferring the investment required for replacing assets by one year would provide £20m of savings.
    - Is our understanding of expected asset life accurate?
    - How can we accurately determine the condition of our assets?
- Environmental classifications: review, propose & validate (deploy sensors/compare existing data sets)
- Artificial ageing: modelling & simulation, validation (deploy sensors/physical testing)
- Condition assessment: developing an efficient condition monitoring regime to determine expected asset life with greater accuracy.

OHL Innovation Workshop: Asset Health

How do we intend to address them?

- *Considering specifically asset ratings;*
- Deferring half of the load related OHL investments identified in NOA until the end of their asset life would result in savings of approximately £9m.
- Review our approach to determining the thermal ratings for circuits
    - Revising our static ratings (route/span specific): review, propose & validate
    - Feasibility of implementing dynamic ratings: determining forecast uncertainty
    - Assessing the accuracy and assumptions in calculating thermal ratings
- Increasing the thermal performance of conductors
    - Considering alternative conductor types that operate at lower temperatures or lower sag
    - Application of coatings/treatments that improve the thermal performance
- Increasing the clearance in critical spans.
    - Adjusting tension
    - Raising the height of adjacent towers
    - Installing insulated crossarms/semi-tension sets (bottom phase?)
- Uprating the voltage of circuits

Have we got it right? What else could we do?

Electricity Transmission

Deeside Centre for Innovation – Workshop

Tom Charton, Deeside Manager

nationalgrid

Overview

- **Key challenges**
- **Deeside Centre for Innovation – in brief**
- **Facilities and test areas**
  - Insulator test area
  - Conductor test area
  - Substation HV test bay
  - 11kV test bay
  - Transformer test area
  - Impulse test bay
- **Discussion (part 1)**
- **Proposals for T2 extension**
- **Discussion (part 2)**

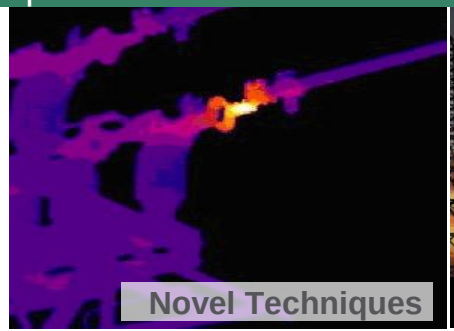
Key challenges

- Net Zero 2050
- Decarbonisation of transport, heat and industry
- System inertia and network stability
- Control system interaction
- Asset life and lifecycle
- Remote monitoring and asset data collection
- System access
- Risk management
- Security and dependability
- Digitalisation
- Cyber security
- Carbon footprint and environmental impact
- Cross vector interaction
- DSO and embedded generation
- Microgrids
- Smartgrid
- Hydrogen economy
- PAC requirements
- System awareness
- Peer to peer transactions
- AI application
- IIoT integration
- Drive efficiency

Deeside Centre for Innovation in T1

£26m NIC Project funded ~50/50 between NGET and NIC

The majority of our innovations and novel technologies presented by our suppliers require accelerated de-risking and more effective implementation into our business.



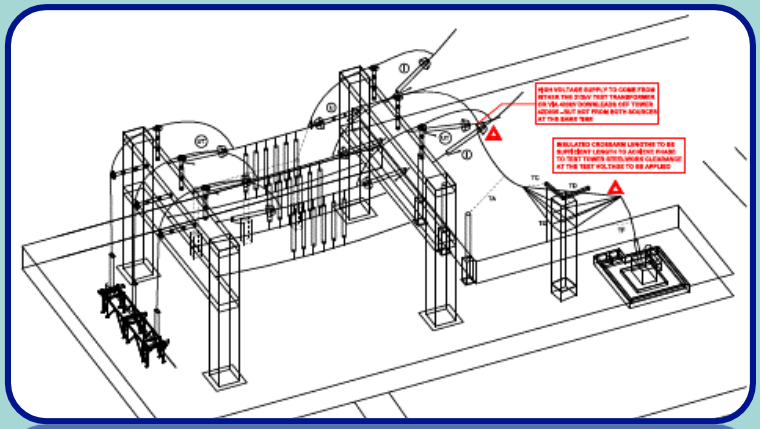
Objective

Develop an environment for testing innovative substation technologies. Consider:

- Assessment of interoperability and interaction of assets and technologies.
- Trial of novel maintenance/refurbishment techniques.
- Load profile cycling to assess impact and speed of ageing.
- First stage of rollout of emerging technologies and novel operating practices.

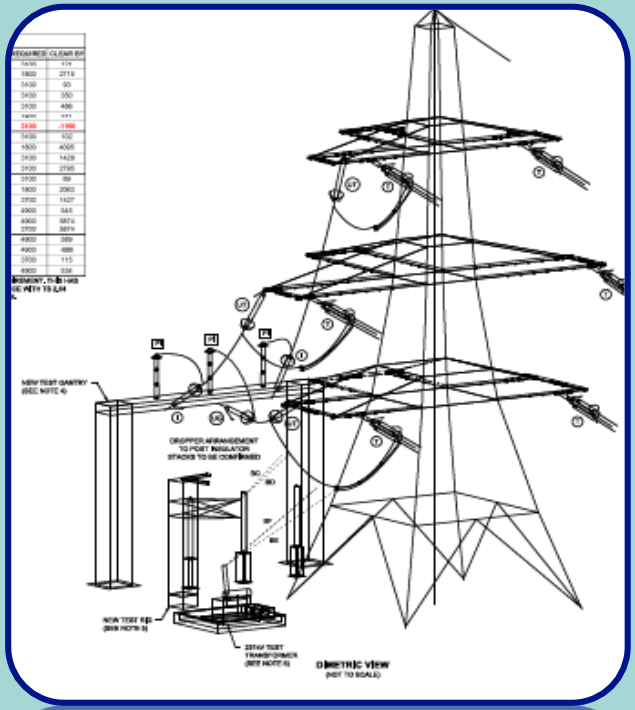

5
Overhead Line Section
4
Substation Section
6
Facilities
1
National Grid Owned Land
A548
Flintshire Bridge
B5129

Facilities and test areas – Insulator test area



- Testing at up to 400kV
- Vertical, horizontal and diagonal orientation
- Long term performance studies
- Environmental impact studies
- Life cycle validation
- Installation techniques
- New product testing

Facilities and test areas – Conductor test area



One of a kind facility for:

- Testing under variable electrical load
- Mechanical loading / stress testing
- Long term performance studies
- Environmental testing
- Life cycle validation
- Installation techniques
- New product testing

Facilities and test areas – Substation HV test bays

- Testing of primary assets at 400kV and 132kV
- High current injection facility
- Long term performance testing
- Environmental testing
- Life cycle validation
- Installation techniques
- New product testing
- Validation of monitoring equipment

Facilities and test areas – Impulse test area

- Insulator tests
- Lightning & switching impulse tests
- EMC tests
- …

Facilities and test areas – 11kV test bays

- Focussing on DNO innovation needs
- 11kV switchgear
- Lifecycle testing
- Condition monitoring
- Secondary systems
- Environmental
- …

Facilities and test areas –TX test bays

- Transformer test bay
  - Performance testing
  - Insulation media
  - Ageing
  - Environmental impacts
  - Maintenance regimes
  - Interfacing to secondary equipment
  - …

Progress update

- OHL area construction ongoing
  - Insulator test area - construction
  - Conductor test area – detailed design
- Delivery planned for April 2020
- Substation area ECI stage
  - Delivery target is Oct 2020 tbc.

- Challenges: e.g.
  - Ground contamination
  - Unique designs

Discussion

- What is (not) essential in terms of facilities and capability?
- What type of testing/services will be required for GB networks? (use cases)
- Which stakeholders need to be included?
- Which other challenges do we need to address as part of our testing facility?

Proposals for T2

- Include energy vectors associated with the Net Zero ambition (eg. hydrogen, natural gas etc.) with the capability for cross vector testing.
- Provide the facility at cost to UK academia and SMEs to test their technologies aligned with the Government's Clean Growth Strategy.
- Investigate how to operationally integrate energy vectors and associated protection and control systems required.
- Investigate the impact of new technologies and operations on existing infrastructure.

Proposals for T2

- Integration of small scale wind and solar generation
- Electrolyser for on site hydrogen generation and storage
- Fuel cell based UPS
- Battery storage for peak load and storage
- Integrated energy management system
- Vehicle to Grid services
- Cable testing area
- Energy vector interaction
- Hydrogen and bio gas testing on GT and GD assets
- Hydrogen appliance test area

T2 Objectives

1. De-risking of the testing, trialling and implementation of clean-energy technologies.

2. Accelerated development of new, whole-energy-system technologies.

3. Delivery of the necessary technology and understanding to deliver our Net Zero 2050 ambition.

Discussion

1. Which other capability, technology, process or opportunity need to be considered?
2. Which stakeholders need to be engaged in the extension?
3. What are potential barriers to the delivery of our objectives?
4. Any other comments and feedback?
5. Getting involved – TAB meeting to be scheduled

Electricity Transmission

Alternatives to SF_6

Gordon Wilson, Senior Innovation Engineer

nationalgrid

Introduction

- **Strategy and Challenges**

- **Ongoing work**

Switchgear and SF_6 Alternative Gas Strategy

"Leading the research and development activities for managing switchgear and SF_6 relevant equipment in an environment friendly and cost-effective way"

Challenges

How can we reduce greenhouse (SF_6) gas emissions by 80% by 2020?

Can we develop an intelligent condition monitoring method for switchgear?

How do we increase the availability of switchgear by reducing the frequency of maintenance?

CF_3I as an alternative to SF_6

- **Trifluoroiodomethane is a possible suitable alternative to SF_6**
  - ✓ Colourless and non-flammable
  - ✓ Rapidly decomposed by sunlight with GWP <5
  - ✓ Improved insulation capabilities in a uniform field
  - × Limited current interruption capability
  - × High boiling point
- **Project investigations**
  - Breakdown voltage characteristics of different CF_3I/CO_2 mixtures
  - Interruption performance of different CF_3I/CO_2 mixtures
  - Surface effects of CF_3I breakdown on electrodes
  - Compatibility of CF_3I with metals and elastomers

Novec 4710™ as an alternative to SF_6

- **Investigating the long-term stability of NOVEC 4710™ mixtures**
  - Stability of C_4F_7N mixtures in the presence of various materials and different working pressures
  - C_4F_7N mixtures with CO_2 or N_2 including G^3
  - Measurement of by-products of the gases selected subjected to electrical flashover and partial discharges
  - Understand the nature of the by-products and effect on the gas properties

Application of alternatives to SF_6 for retrofilling

- **Investigating the suitability of NOVEC 4710™ mixtures in existing equipment**
  - Retrofilling GIL/GIB not switchgear
  - Performed LI/SI and AC withstand tests on medium scale test vessels showing equivalent performance with SF_6 at 420 kV
  - Testing at 550kV in progress
- **Proposal for Deeside testing**
  - Develop new set-up for long-term energisation at Deeside test centre
  - Develop retrofilling procedures
  - Perform on-site testing and diagnostics

Electricity Transmission

Transformer Innovation Workshop

Gordon Wilson, Senior Innovation Engineer

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Introduction

- **Wound Plant strategy**
- **Project Highlights**
- **Stakeholder Event feedback**
- **Project Ideas**

Wound Plant Strategy

"Optimising the use of new and existing transformers, mindful of the impact of transformers on the environment and the effect of the changing environment"

Highlights in RIIO-T1

- **26 Projects completed so far**
- **£12m invested, £42m value of investments, £115m expected benefit**
- **Outcomes**
  - Sufficient learning about asset condition and deterioration to extend asset lives
  - Investigation of corrosive sulphur to understand mechanism of failure
  - Fundamental research required for the construction of compact urban substation at Highbury with synthetic ester filled power transformers at 400 kV
  - Optimised location of surge arresters
  - Installation of reduced maintenance transformer dryer
  - Robot internal inspection of transformer

Innovation horizons

Core

Incremental changes to the way we do things to make them more sustainable

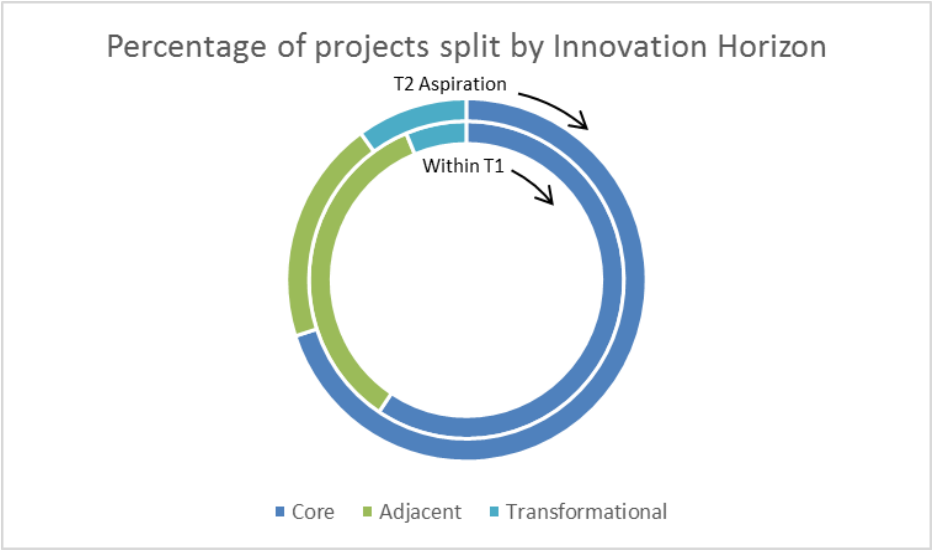
Adjacent

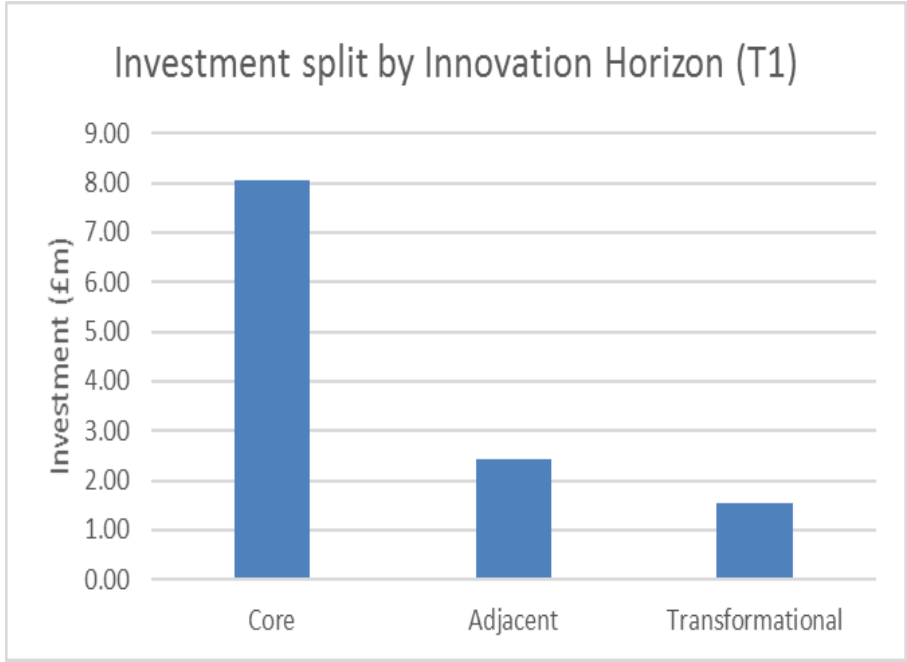
Breakthrough innovations taking advantage of new opportunities by transferring technologies

Transformational

Disruptive changes that result in significant benefits by revolutionising ways of working

Transformer projects





Challenges

Increase the amount of power that we can push through a transformer

Reduce the time taken or cost of a transformer replacement or new installation

Make our transformers more environmentally friendly

Challenge the standard assumptions associated with ratings

Consider LIDAR for modelling replacements

Increase monitoring on bushings

Renewable technologies for transformer cooling

Consider your TRL for projects

Consider harmonics from increased loads

Single phase transformers can be replaced individually

3D printing to replace hard to source parts

Any innovation for instrument transformers

Digital twin of whole system including softer human factors, cyber security and interfaces with old tech

Response to feedback

Updated the Wound Plant Strategy

- Expanded the scope of the portfolio
- Captured feedback as part of a Stakeholder Engagement section
- Strengthened the strategy in the area of Corporate Responsibility
- Identified a need for Transformational Projects

Engaged with suppliers to discuss new projects

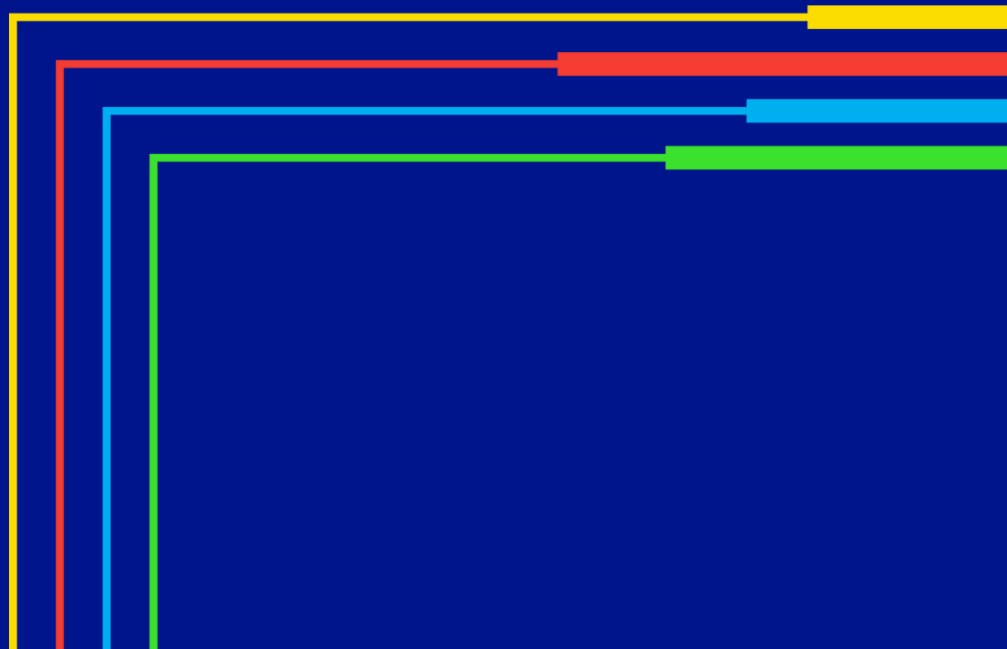
- Bushing monitoring/assessment
- Investigating barrier board degradation to confirm safe access into confined space
- Laser vibrometry of defective porcelain
- Novel cooling options for transformers

New project – Economic Ageing of Transformers

Project Ideas

- Barrier board condition monitoring
- Lifetime performance of DGA monitors
- Geomagnetic Induced Currents
- Fire damage zones
- Heat recovery, storage and energy conversion
- Visual markers for switch oil
- Bushing monitoring
- Laser vibrometry of porcelain insulators
- Development of active noise control

Feedback forms are on your tables please complete



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