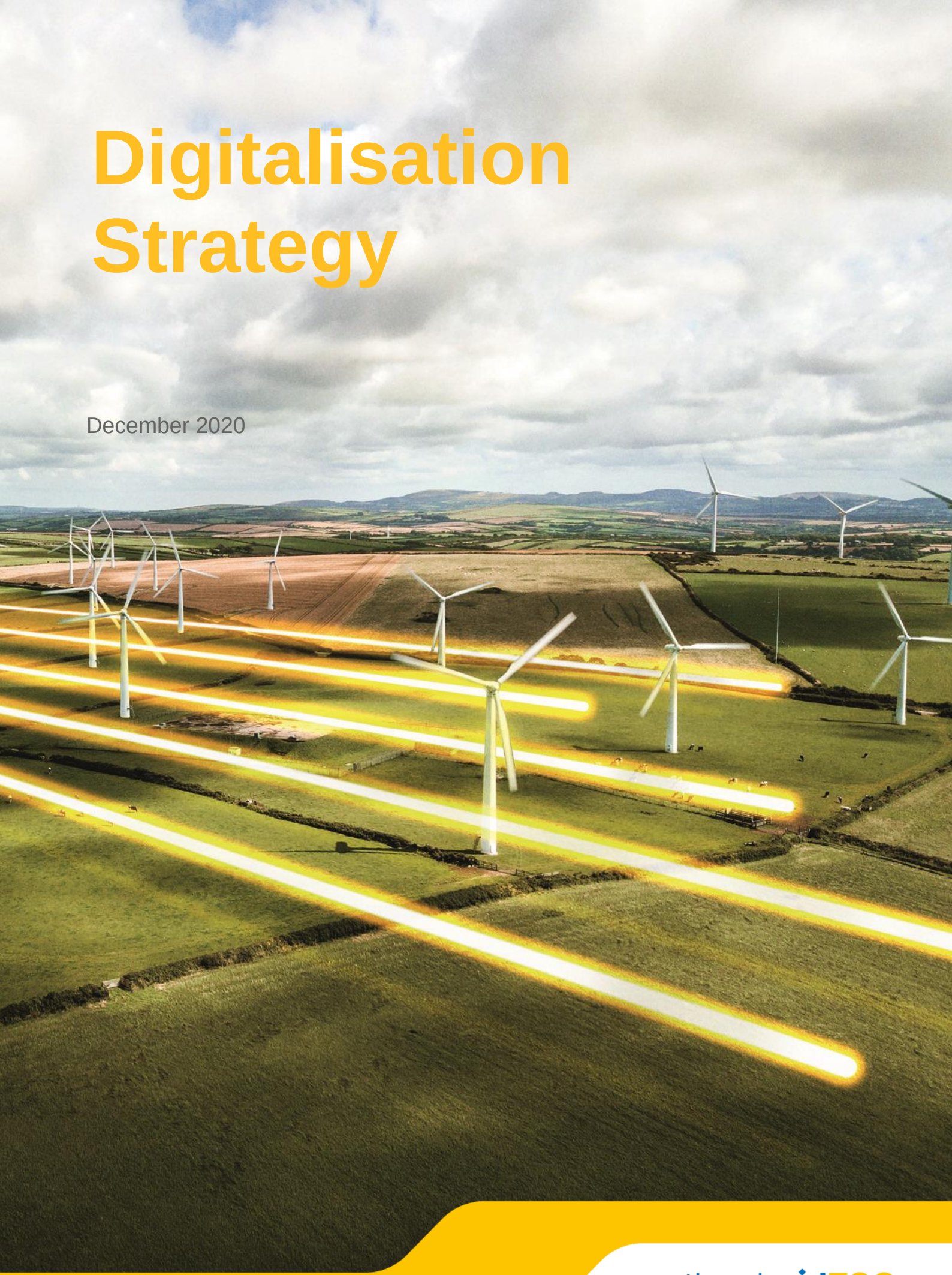
Digitalisation Strategy

December 2020



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1. Introduction and context

1.1 Document development

Following submission of our Digitalisation Strategy in December 2019, in parallel with our RIIO-2 business plan submission, Ofgem issued an Open Letter[1] on 10 June 2020 to all network companies. This set out their overall evaluation and common feedback on all the strategies they had received. They also made a commitment to provide ad hoc feedback to each network company to support the required update of the Digitalisation Strategy and inclusion of a Digitalisation Action Plan by 31 December 2020. In response to this commitment we held a bilateral with Ofgem on the 7 August 2020 to receive their specific feedback to inform the improvement of our Digitalisation Strategy and Action Plan (DS & AP).

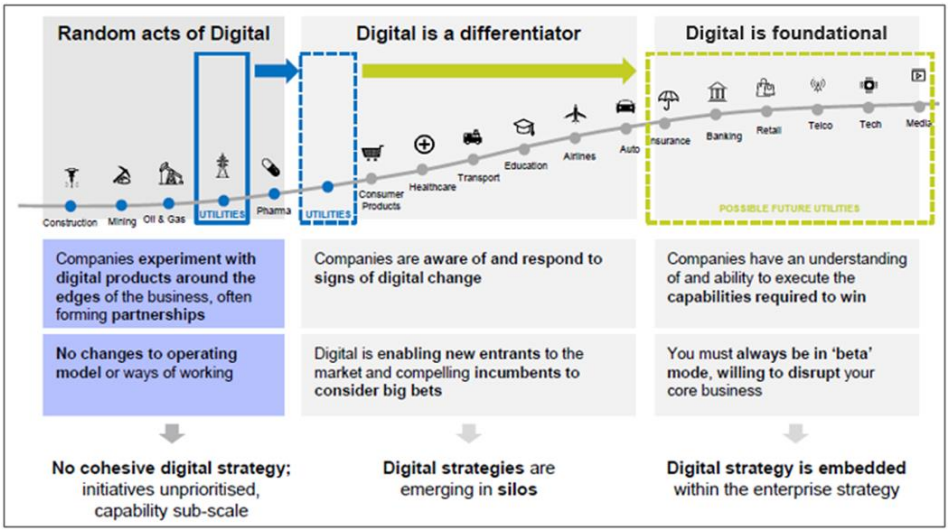
1.2 ESO mission and success in 2025

We are clear about our mission and what success looks like in 2025. We are committed to realising the benefits digitalisation of the GB energy system presents for our customers and recognise the central role and responsibilities the ESO has in enabling the required energy transition. A transition that, through greater transparency and open data, will unlock significant value to the consumer and wider society; sustaining energy affordability and accelerating decarbonisation of the system, whilst enabling our customers to help us innovate and support us in ensuring system reliability and security.

Digitalisation is one of our industry's strategic drivers, alongside decarbonisation, democratisation of data and decentralisation. Open data and digitalisation underpin the whole system thinking required to achieve net zero. This is key to navigating increasing complexity at lowest cost for consumers. It is a key enabler to our overall mission and links to our four 2025 ambitions, other strategies and investment plans. It is an integral part of establishing an effective and efficient ESO.

Our mission:
To enable the transformation to a sustainable energy system and ensure the delivery of reliable, affordable energy for all consumers
Success in 2025 looks like: • An electricity system that can operate carbon free • A whole system strategy that supports net zero by 2050 • Competition everywhere • The ESO is a trusted partner

The scope of our Digitalisation Strategy is consistent with our first submission, is aligned with the four themes we employed in our RIIO-2 business plan and addresses the common and specific areas of improvement identified by Ofgem. As we recognised in our RIIO-2 business plan and as illustrated in this chart, compared to some other sectors, utilities are in the early stages of digitalisation.



Our vision for our technology is to progress through greater levels of integration and use proven technologies and methodologies to transform traditional models of doing business within the energy sector. We will ensure that in addition to maintaining safe, reliable system operation and managing risks appropriately, we support an open, accessible market where anyone can participate and a network than can run carbon free. This will require increasing the amount of back-office automation, data-driven decision making and increased customer

[1] Ofgem open letter - https://www.ofgem.gov.uk/system/files/docs/2020/06/open_letter_digitalisation_strategies_feedback.pdf

insights through analysis of customer journeys. Achieving our digital ambitions will further require us to reconsider our culture and ways of working.

This digitalisation strategy sets out how we will modernise our tools and processes, through the usage of digital technology, establishes the additional skills and capabilities we require, and sets out the cultural transformation that we must carry out.

We will achieve our Digitalisation Strategy by delivering an ambitious set of activities and programmes. As highlighted in the following chapters these have been informed by our services and data users / consumers and wider stakeholders' priorities and needs; and will be delivered, where relevant, in co-ordination and collaboration with other network companies and energy system partners.

We have also highlighted where we support the recommendations of the Energy Data Taskforce (EDTF)[2] as we recognise the leading role we will play in their delivery. We reference where we are already demonstrating our work in this area in this document, with further details in our Digitalisation Action Plan. Our Digitalisation Action Plan, attached to this document, provides a detailed view on the delivery of our ongoing and planned activities. This includes, by each pillar, our activity and deliverable road-maps, and the enabling technology investments; providing a detailed view of how we have defined success and will measure progress.

1.3 Governance

ESO leadership is fully committed to show senior ownership and ESO Board accountability of our Digitalisation Strategy and Action Plan. A full articulation of our structure and approval processes to meet these requirements in RIIO-2 has not been fully developed at the time of this document's publication, as the final details of the ESO IT model were made available only a few weeks ago. Our next Digitalisation Strategy refresh will have the details on how it will all come together.

While our internal structure is yet to be fully matured, we fully recognise the opportunity to be more transparent in our change delivery. Our 2025 zero-carbon ambition will need the support, insight and experience from the wider industry to help guide and inform the delivery of our transformational proposals. We committed in our RIIO-2 business plan to introduce a cross-sector Technology Advisory Council (TAC)[3]. It will set the guardrails for our system transformation, provide stakeholders the opportunity to be involved in our strategic decision-making, and afford greater visibility and confidence of agile, transparent delivery. In addition, it will leverage the expertise of out-of-sector of organisations who have been through similar transformations.

We engaged extensively on the creation of the TAC during the development of our RIIO-2 Business Plan.

At an overall level, the TAC will:

1. Help set the **strategic direction** of the ESO transformation journey in systems (including process and technology) development
2. Provide **stakeholder input** into the ESO transformation, ensuring the changes we make reflect wider market needs
3. Bring **transparency** around our decision making and help the ESO communicate change externally in the appropriate manner. This will help stakeholders plan their own IT system changes, including those that will interface with the ESO
4. Ensure **accountability** from the ESO for delivering on its promises and proactively communicating changes
5. Allow us to consult and engage on the experience of interacting with the ESO and **invite input into key design, development and testing phases of our solutions development**. It will also provide transparency of the decision-making logic behind our systems

We envisage the TAC having a strategic layer and a technical layer. The strategic TAC will help set the requirements for solution development, with the technical levels overseeing design, testing and implementation.

The exact structure will be decided in the final terms of reference which will be agreed by the group in the first meeting. The TAC group has been modelled on the ESO RIIO-2 Stakeholder Group (ERSG)[4].

[2] EDTF Recommendations - https://es.catapult.org.uk/reports/energy-data-taskforce-report/

[3] In our RIIO-2 Business Plan and associated stakeholder engagement, the TAC is referred to as the Design Authority

[4] https://www.nationalgrideso.com/our-strategy/business-planning-riio/riio-2-stakeholder-group

We envision the TAC having a strong influence on setting the overall direction of our Digitalisation Strategy, and on holding us accountable to deliver our Action Plan.

As per our final determinations, we are committed to refreshing our Digitalisation Strategy every 2 years, by collaborating across the business as well as by consulting with our customers and stakeholders, to ensure we capture their observations and suggestions. Similarly, we will ensure our Action Plan is reviewed every 6 months.

1.4 Considerations

In reading this document please note that it has been prepared for the most part in advance of the following items. These are expected to have a bearing on our strategy and how we deliver it:

1. Final determinations
2. ESO IT Model
3. BEIS / Ofgem Data Strategy
4. Government review of the system operator

2. Ambition

We're in the midst of an energy revolution. A range of factors can be said to be driving change in the energy industry, and chief amongst them are what we call the three Ds – decarbonisation, decentralisation and digitalisation. However, when it comes to Data, we should be adding the fourth D, democratisation.

The global focus on climate change rightly puts decarbonisation high up political and social agendas across the world, and decentralisation is an increasingly well-understood concept – even outside the energy sector – as the growth in community renewables and local schemes sees the locus of power generation and transmission move closer to consumers, towards regional models.

But what do we mean when we talk about digitalisation? As the energy landscape evolves, the digitalisation of our electricity system is key to driving innovation and to capturing the benefits of our transition to zero carbon. Furthermore, democratisation is impacting our relationship with our customers and stakeholders by bringing data to the core of our interactions, ensuring that we can leverage the industry's combined ingenuity and tools in tackling what has been termed as the challenge of our generation, climate change.

2.1 Vision

For National Grid ESO, this means harnessing digital technologies to enhance our operations, whether that's in energy forecasting or hope for network planning. We're already making strides in this area, with artificial intelligence supporting our control room activities, and projects such as our link-up with the Alan Turing Institute boosting our forecasting capability through machine learning.

Digitalisation also means taking the increasingly complex 'big data' that underpins everything we do and making it accessible in a way that will help industry's transformation towards sustainability. We know that in our role as the system operator, we're custodians of a lot of data on the electricity network, and that it's our responsibility to collect, analyse and share it transparently and responsibly – allowing its value to be unlocked.

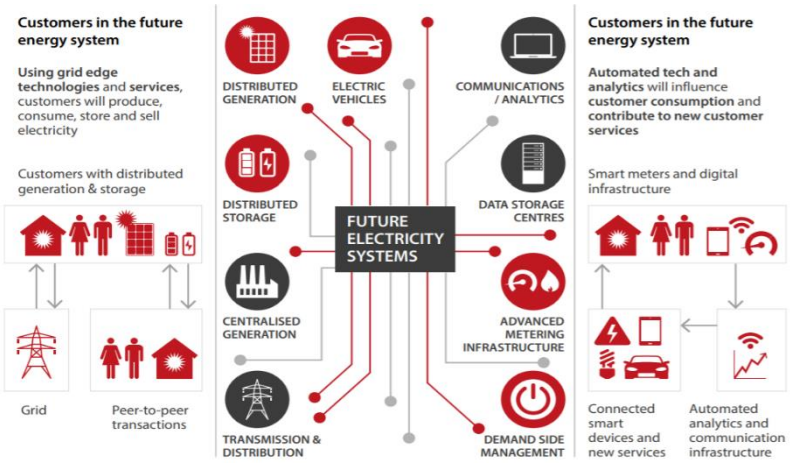
Open data is very much the lifeblood of an efficient energy system and market, changing the way market participants interact with us and each other and enabling them to make informed choices. That's why we've made commitments in both our RIIO-2 business plan and our forward plan to 2021 to put it at the heart of our strategy and vision for the next decade and beyond.

We've already begun evolving our data-sharing platforms to meet the demands of today's more data-intensive energy ecosystem. We're in the early stages of this journey, and our first milestone is the development and rollout of a new pilot data portal to support our ambition to make our data easier to discover, understand and consume.

3. Market drivers and development

The GB energy landscape is undergoing a significant transformation as a result of decarbonisation and decentralisation of power generation and distribution. Low-carbon records are constantly broken and there is increasing interaction between fuels and across different industries. As a whole, the energy sector is moving away from being siloed, becoming more integrated and multi-vector. The transformation, however, is not homogenous: network companies, customers and stakeholders are at various stages of maturity in leveraging the value of data for consumers, stakeholders and wider uses. The democratisation of data, through greater transparency, presumed open access and sharing is especially driving digitalisation across the whole system.

EnergyRevs[5] has developed what a future decentralised, data and digital enabled energy system looks like (based on a World Economic Forum view from 2017). Their figure opposite demonstrates how society's relationship with energy will change through greater involvement, new types of participants and increased volumes of and presumed open access to data.



We are already experiencing the implications of greater system integration and centralisation, including the emergence of new players in the energy sectors, such as:

- suppliers competing with digital, non-commodity and low-carbon offerings;
- flexibility digital platform developers and operators;
- start-ups creating value from consumer data (mainly in the electric vehicle space)

To deliver the significant transformation needed to meet net zero, even greater whole system thinking is required, and in order to achieve this we must significantly increase our interactions amongst industry participants and ensure wider and secure data sharing amongst the relevant players. As stated in our Future Energy Scenarios 2020: **Open data and digitalisation underpin the whole system thinking and is key to navigating increasing complexity at lowest cost for consumers**.

As further set out in our FES[6] and on our Bridging the Gap to net zero[7] work, achieving net zero will result in a very significant increase in electricity consumption, along with increased intermittency of generation and potentially increased "spikiness" of demand. Innovation in data and digitalisation is therefore essential to meet such challenges, and to ensure we can continue to do so in the most efficient manner.

Energy system data creates value for consumers in 2 ways:

- By allowing the parts of the energy system access to the same consistent data, thus allowing them to work together more efficiently, lowering the system costs that get recovered via network charges.
- By providing relevant data to all network users allowing them to find their own value including through innovation and adaptations to the way they interact with the system.

An example of how consistent Data can drive a more efficient and secure system, is our Future Energy Scenarios. Currently our Future Energy Scenarios are being used as the starting point for many processes in the energy sector. Specifically, the numerical data within the scenarios, underpins further analysis related to future network needs. This includes the use within the Electricity Ten Year Statement and Network Options Assessment process to help identify future network boundary constraints and the cost-efficient options to overcome them, respectively. We also currently publish the data as Excel files which anyone can use so that they can import it directly into their processes.

[5] EnergyRevs working paper on Digital Energy Platforms - https://www.energyrev.org.uk/
[6] Future Energy Scenarios - https://www.nationalgrideso.com/future-energy/future-energy-scenarios
[7] Bridging the gap to net zero - https://www.nationalgrideso.com/future-energy/future-energy-scenarios/bridging-the-gap-to-net-zero

In order to drive further cost efficiencies as the GB energy sector and wider economy transitions to net zero, it is expected that our data requirement is expected to increase, potentially exponentially. The sections below set out some of the changes that we expect.

3.1 Networks

With the number of energy participants rapidly increasing, the complexity of energy network design decisions is also increasing. Combined with greater interaction between energy vectors (fuels) this will result in a greater need for data in order to ensure that efficient choices are made as the system progresses towards net zero.

There is likely to be greater emphasis on local energy systems linked to the geographical differences across Great Britain. This has implication for not only how energy is supplied but also how it is consumed. Access to data from within the energy industry and also external to the energy industry is required to underpin the analysis of future energy needs thereby ensuring that design choices can be robustly challenged and efficient choices progressed.

Where there is more flexibility of the placement of assets this creates an opportunity to avoid network reinforcement as the traditional form of resolving constraints. Data is required to assess these options and test the effectiveness for all parties – for example the siting of electrolysers will need to consider both the impact on the electricity network but also the gas or hydrogen network.

The networks will also need to ensure continued access to their assets for the purpose of ongoing maintenance. As the energy flows across the networks become more variable and dynamic, it becomes harder to plan for outages. Data that would support short to medium term forecasting will help mitigate this, as would information about how flows could be reconfigured at lowest cost.

3.2 Consumers

Consumer choices today and in the future will influence decarbonisation pathways and options for efficient whole system operation. Consumers will have an expanding role in achieving net zero through changing behaviours such as by altering their consumption patterns (e.g. smart appliances, thermal or electrical storage and vehicle to grid) or by self-generating power locally (e.g. solar PV). Savvy consumers may want to make their own choices here in which case they will be looking to the energy industry for data and insights that support their decision making. Alternatively, consumers may look to third parties such as suppliers to optimise their energy usage on their behalf. In this latter case the consumers themselves will become a valuable source of data for the industry.

As consumers become more active market participants, they will demand systems that are simple to interact with. They will need to register their assets and provide energy system services via digital platforms they can easily join, operate and leave.

Making the switch to low carbon heating requires complex decisions and policies to be implemented. At this stage it is not clear what degree of choice the end consumer will have as some solutions may be specific to particular regions within Great Britain. Nevertheless consumers, and those supporting the decision making on behalf of consumers, will require access to data to ensure cost optimal choices are made.

New large and potentially flexible electrical loads (e.g. heat pumps and EV charging) will mean that individual consumers will have a bigger impact on the whole system than they do today. Thus, consumers themselves may need to provide data to third parties – such as their consumption patterns, details about the energy efficiency of their home and their lifestyle – in order for solutions to be tailored to their individual needs. Access to consumers' increasing volumes and types of valuable data will need to be supported and safeguarded.

Mobility as a service and as autonomous vehicles has the ability to change the way we travel but this will also affect the way energy is consumed and supplied too. In particular, commercial operators of shared fleet vehicles have different choices to make than individuals would under private ownership. For fleets of vehicles provision of vehicle to grid services would come at the cost of having that vehicle stationary and not available for mobility services. Data will need to be brought together from both the energy and transport side in order to assess, predict and deploy solutions.

3.3 Generation and flexibility

As set out in our Future Energy Scenarios, we see substantial increase in the amount of renewable generation capacity on the system. As much of this is weather dependent it will need to be supported by technologies that can flex up and down in order to ensure that demand and supply match on a second by second basis. Some of the potential technologies create links between networks either of the same energy vector (as in the case of interconnectors linking GB to its neighbours) or between energy vectors (as in the case of electrolysers that convert electricity to hydrogen). Some are also looking at linking different industries, such as smart charging and V2G (mobility – energy) and braking energy (rail transport – energy), amongst others.

With a need to address both national and regional needs, generation and flexibility is likely to come from a range of assets including both large/centralised and smaller/decentralised distributed energy resources (DER). Determining which assets to build, where and when, will require further data sharing in order to reduce potential risk of stranded assets and the cost associated with this.

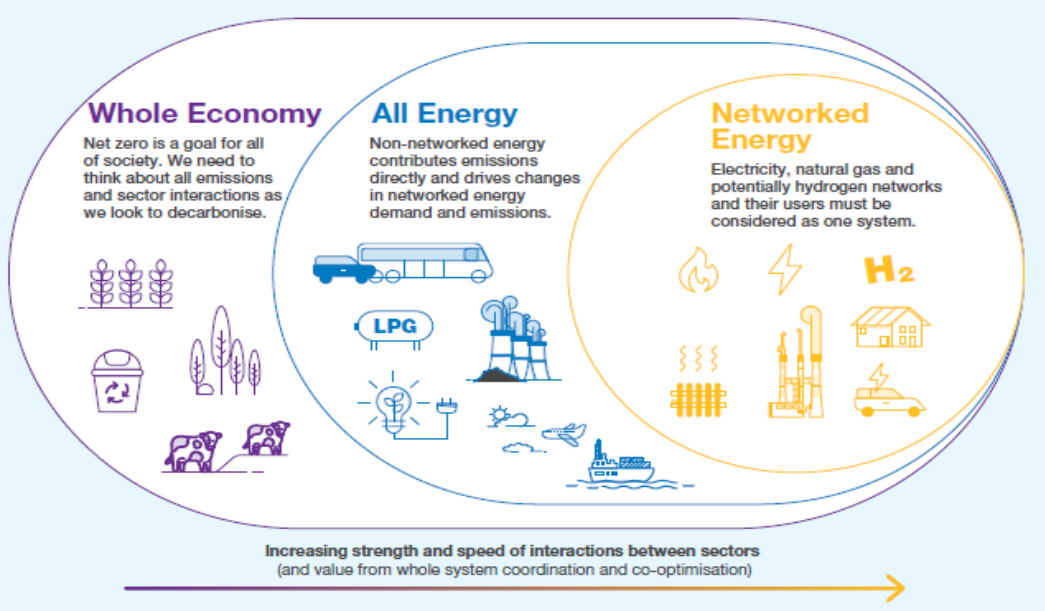
Flexibility is seen as a key component for delivering value for consumers in a net zero economy. Cost effectiveness will require large volumes of open data in order to both squeeze out the most value from flexibility, but also to create confidence that the system can rely on this flexibility in order to overcome the peaks and throughs created by a highly renewables dominated generation mix.

Data will be required by both the owners of flexible assets but also other users of those assets. At times multiple stakeholder interactions with flexibility will need to be effectively resolved. For example, a domestic owner of a flexible asset will want to receive external data signals in order to maximise individual gain by responding to a varying price, whilst other users of flexibility (e.g. ESO, DSO) will need to be continuously estimating how much flexibility it will get from all homes that evening (e.g. how “firm” that resource will be in providing that service) and therefore how much to secure from other sources. During some periods, different users of the same flexibility asset may desire different outcomes and to resolve these computational and data intensive process may be required (similar to how owners of the current generation assets assess how best to respond to the market, but this will need to work automatically for potential hundreds of thousands of flexible assets).

3.4 Wider energy landscape and economy

The increasing need for and value in the electricity flexibility system will result in other energy systems and the wider economy becoming more closely integrated with electricity so that they can provide some of that flexibility. A particularly strong link occurs when energy is transferred between systems (e.g. between the gas/hydrogen and electricity systems via hydrogen turbines and electrolysers). These interactions will be much more efficient with good data flows between the systems.

The diagram below shows that some parts of the system will be more closely interconnected, with stronger and faster effects on each other, than other parts. There will be a much larger and faster flow of data between these more strongly connected parts.



4. A stakeholder driven digitalisation strategy

4.1 Ongoing engagement

Engaging with a wide range of stakeholders, including current and potential service providers, generators, networks and network operators, academics and energy users has been central to the development of this Digitalisation Strategy and will be even more so in our future ones. We will refresh our digitalisation strategy every two years, so ongoing engagement will be key to maintaining our understanding of and alignment of our digitalisation activities to the ever-changing challenges they face, as the electricity system and markets transform and our users' services and data needs and expectations change. Our customers and stakeholders have also told us that they want us to develop improved communications channels that not only give them access to self-serve data but also enhance the effectiveness of our communications.

We will build on the success of engaging our stakeholders through the mechanisms we employed to jointly develop our RIIO-2 business plan. We will maintain appropriate digital channels and establish the right end-to-end processes to improve our capabilities in stakeholder management, customer engagement and data management. We have set-up a team focused on enhancing our customer and stakeholder engagement experience, to ensure we continue to align our activities to their needs and identify new opportunities to improve and co-ordinate our co-creation efforts with other network companies and wider stakeholders, such as establishing an industry-wide, digitalised asset register.

We will continue to seek input and feedback from this community through existing channels and wider stakeholder forums including:

- our new Technical Advisory Council will give stakeholders the opportunity to input into key design, development and testing phases of our solutions. This forum will provide an excellent opportunity for stakeholders to provide input into ongoing development of our Digitalisation Strategy,
- our annual Open Innovation call for ideas[8] through which parties can propose innovative solutions to address our priority areas including digital transformation, system stability and whole electricity system,
- our Electricity Operational Forums, regular meetings with our electricity customers to discuss the operation and performance of balancing services markets, are an excellent opportunity for stakeholders to tell us how we are performing against our open data and digital market enablement goals,
- our Bridging the Gap, Data and Digital workstream, where we are engaging a group of core stakeholders, via virtual workshops and employing an agile, sprint approach, on the new peaks/troughs we could see in our energy system from now to 2030 as it continues to decarbonise, and how markets, technology and data and digitalisation can help to mitigate these challenges,
- the Energy Networks Association Data Working Group and the National Energy System Map Sub-Group. Our engagement with this sub-group will help enable all geo-spatial data related to network infrastructure, across all network companies, to be harmonised in terms of standard data classification, develop open data sets and enable them to be shared and exposed effectively to end consumers. We have also committed to the Coordination Sub-Group which aims to maximise the value of digitalisation and data investment by: identifying coordination/ collaboration opportunities for the benefit of customers via ENA member companies and existing gaps in industry and wider industry digitalisation and data activities, setting priorities and proposing/ developing new tools to assist in the management and knowledge capture of digitalisation and data projects,
- Ofgem's/BEIS Data & Digital Service Providers forum, where we have been actively engaged from the start and openly sought wider stakeholder views on the development of our data strategy and so inform our digitalisation strategy.
- and our past active participation in the Energy Data Taskforce, where we were able to support the shaping of the Open Data principles and contribute to its incorporation into all networks' Digitalisation Strategies.

[8] ESO Open Innovation - https://www.nationalgrideso.com/innovation/news-and-events/open-innovation-event

4.2 Consumer and stakeholder priorities

Our planned data and digital activities have been informed by significant inputs from a broad range of consumers and stakeholders, throughout our RIIO-2 business planning process. These activities are set out in the following sections, under our three strategic digitalisation pillars. This approach has enabled us to establish both our user journeys, reflecting what they do now and what they want to be able to do in the future; and their priorities. The user journeys are set out in the main document and appended (see appendix A) and the table below summarises their priorities against our roles. Further details of what our stakeholders have told us set out in our RIIO-2 business plan Stakeholder Report[9].

	Role 1 (Theme 1) Control centre operations	Role 2 (Theme 2) Market development and transactions	Role 3 (Theme 3 & 4) System insight, planning and network development
Consumer priorities	• We want an affordable energy bill • We want energy to be available when we need it • We want a decarbonised energy system, fir for our future • We want a safe and secure energy system	• We want an affordable energy bill • We want a decarbonised energy system, fit for the future • We want a safe and secure energy system	• We want an affordable energy bill • We want energy to be available when we need it • We want a decarbonised energy system, fir for our future
Stakeholder priorities	• I want efficient whole energy system operation • I want you to be open, engaging and easy to work with • I want you to be adaptable and innovative • I want to provide more balancing and ancillary services	• I want transparent and forecastable charges • I want efficient whole energy system operation • I want you to enable the smart and low carbon energy system of the future • I want you to be open, engaging and easy to work with • I want you to be adaptable and innovative • I want you to facilitate active markets for a wide range of products and services • I want access to comprehensive accurate and user-friendly information	• I want efficient whole energy system operation • I want you to enable the smart and low carbon energy system of the future • I want you to be open, engaging and easy to work with • I want you to be adaptable and innovative • I want to provide more balancing and ancillary services • I want to connect to the electricity network in a timely manner

4.3 Stakeholder views on open data, effective digitalisation and ways of working

The success of the current Digitalisation Strategy is heavily dependent on appropriate stakeholder engagement. We recognise that in addition to the Consumer and Stakeholder already captured, a continuous level of engagement regarding views on open data, effective digitalisation and ways of working is required. As such, we plan to further engage with our stakeholders by introducing surveys that ultimately reflect their views and needs which aim to serve not only the ESO Digitalisation Strategy but the wider industry of what a successful digitalised energy sector looks like.

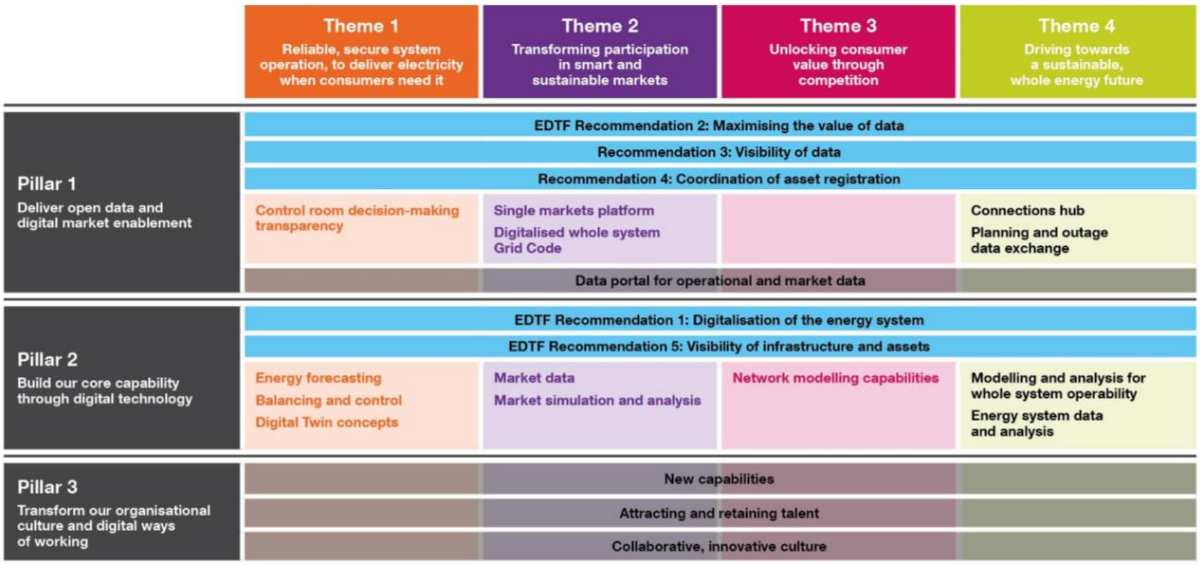
5. Creating a data and digital driven ESO

We will establish both our main enabling data and digital related activities and the related activities that use them, to create a seamless user experience. These activities have been informed by the views and needs of our current and wider external customer and stakeholder community and our internal consumers / users. The detailed views of our external stakeholders across all our planned activities are set out in our Stakeholder Report[10], submitted with our RIIO-2 business plan.

[9] ESO RIIO-2 Stakeholder Report - https://www.nationalgrideso.com/document/158066/download

[10] Stakeholder Report - https://www.nationalgrideso.com/document/158066/download

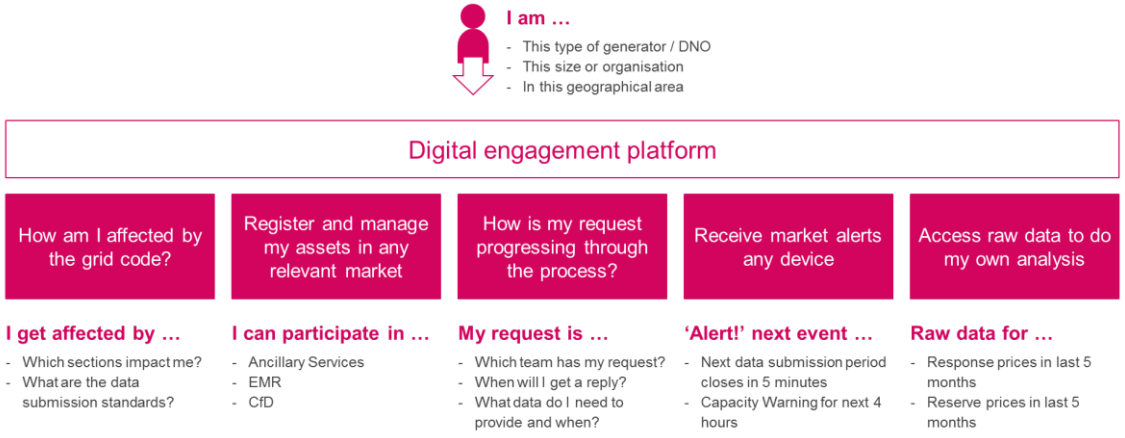
The chart below reflects the scope of our digitalisation strategy within our strategic pillars, business plan themes and the application of the recommendations of the Energy Data Taskforce (EDTF)[11]. We have structured both our Digitalisation Strategy and Digitalisation Action Plan by these three pillars and the planned, enabling activities relating to them.



5.1 Pillar 1 - Deliver open data and digital market enablement

We need to attract new sources of flexibility to support the operation of a reliable and secure zero carbon electricity system at least cost to consumers. This pillar is key to maximising participation in efficient markets. Open data will enable efficient investment and operational decision-making and drive innovation across the industry. Digital market engagement will remove barriers to market participation, increasing efficiency of markets.

Across all our activities we will be using a Digital Engagement Platform to create a seamless user experience for doing business with us. The chart below summarises the overall user journey informing the development of this platform.

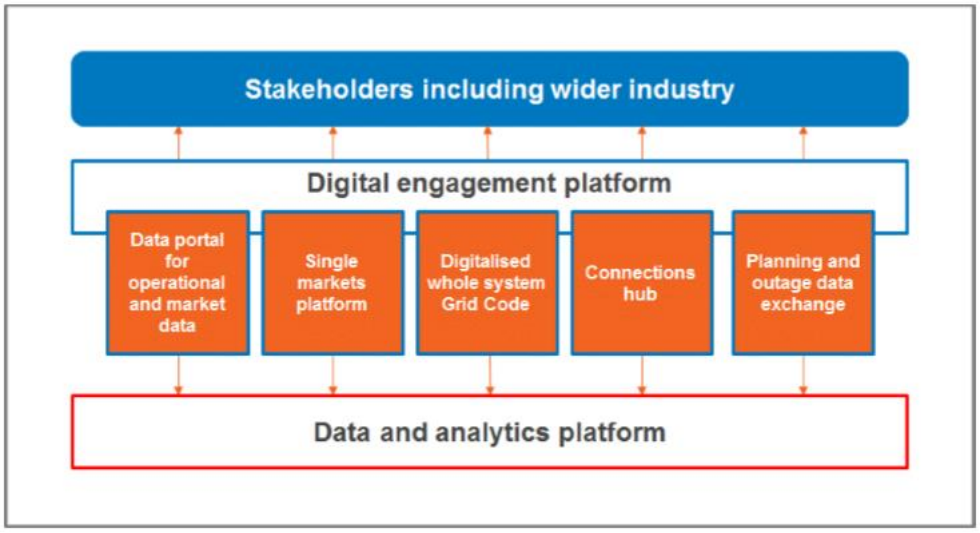


Our customers and stakeholders will be able to access services and data through the digital engagement platform. All external-facing processes will be driven and updated from the digital engagement platform and new tools will be introduced to support document management, collaboration, digital rights management, version management and workflow planning. The figure also illustrates how those services will use the capabilities of the foundational data and analytics platform to share data. The major planned activity uses of the digital market engagement platform explained in this chapter include:

- Data portal
- Connections hub

[11] EDTF Recommendations - https://es.catapult.org.uk/wp-content/uploads/2019/06/Catapult-Energy-Data-Taskforce-Report-A4-v4AW-Digital.pdf

- Single markets platform
- Digitalised whole system Grid Code
- Planning and outage data exchange.



Below is a summary of our planned activities to deliver open data and digital market enablement. For further details on these activities and our stakeholder's views please see our RIIO-2 Business Plan[12], Stakeholder Report[13] and Technology Investment Report[14].

5.1.1 Open data enabling efficient markets and zero carbon system operation

With ever-expanding digitalisation, the availability of quality data will be increasingly fundamental to developing new markets and empowering efficient decision-making.

To realise that potential, our stakeholders have told us that the energy industry must transform the way in which data is managed, structured and shared. We must move from a world where there is very limited access to usable data to one where data is seen as open and shareable by default, both accessible and fit for purpose.

Understanding current and future trends in both the technical characteristics of system operation, such as constraints and inertia, and market dynamics, such as prices and volumes, can help market participants identify future opportunities for solutions to benefit consumers. Current and potential market participants have told us enhanced data and insight are essential for price discovery, efficient investment and operational decision making.

Stakeholders have also told us that the initial areas we should focus on are forward looking view of system requirements; a whole electricity system view of constraints; and real-time margins and utilisation. Providing insights into future balancing service requirements will enable better investment decisions and innovative solutions to manage operability challenges, thereby reducing costs for consumers.

In addition to raw data, where our stakeholders identify a need, we will continue to provide analysis, insight and guidance to support and understand our data. For example, balancing market participants have identified better understanding of control room decision-making processes as a key area. We will explain how control room decisions are made, referencing the relevant data.

Sharing our data and providing enhanced transparency will lead to investments in the services that society needs, so they will be available when consumers need them. This information also supports the optimisation of operational and commercial decisions in market timescales, driving market efficiency

5.1.2 Strategic actions to deliver open data

Data Portal

As one of the main custodians of energy data in the UK, we will play a central role in fulfilling its potential. As the number and diversity of market participants continues to increase, system operation moves closer to real

[12] ESO RIIO-2 Business Plan - https://www.nationalgrideso.com/document/158051/download
[13] Stakeholder Report - https://www.nationalgrideso.com/document/158066/download
[14] Technology Investment Report - https://www.nationalgrideso.com/document/158071/download

time and whole electricity system solutions are developed; the data sources we use to operate the system and markets will also increase. To maximise the value of our data and respond to our stakeholders' needs, our default approach will be: all the data we hold is 'presumed open' unless subject to commercial, legal, network or cyber security risks or restrictions. In support of this we intend to adopt a licensing approach based on the Open Government Licence[15].

Our work on open data will support the development of industry-wide data management tools such as the Data Catalogue, **EDTF recommendation 3: Visibility of data**. We expect a wide range of parties to use data we share to innovate, imagining new solutions to system operability challenges and optimising market efficiency.

We are currently developing a foundational data portal, which will initially address the issues our stakeholders have voiced around the accessibility, understanding and consumption of our data.

Through this portal, we will create a centralised repository for all published ESO data; we will develop a clear and intuitive user interface for searching and querying our data. It will allow us to add rich metadata to each dataset and a powerful Application Programming Interface (API) for all datasets. Additionally, it will offer features such as on-screen visualisation and data manipulation tools to support understanding and consumption. This is in-line with resolving the challenges of data inter-operability and ease of access and discoverability, as highlighted by the **Modernising Energy Data Programme[16].**

Supported by underlying changes to our data management capabilities, we will continually transform the quantity and quality of the datasets we make available. The implementation of the data and analytics platform, outlined in Pillar 2 will allow real-time access to all our operational data, allowing us to automate data publishing and to add new datasets quickly and efficiently

From the start of the RIIO-2 period we will assess, validate and structure all of our operational and market data, sharing it according to published criteria. We will first target datasets identified as of highest value to stakeholders and aim to have published all our relevant data by the end of the period.

In the first year of the RIIO-2 period we will publish a schedule for sharing our data on the ESO portal, providing a clear roadmap for when we will make datasets available.

All published datasets will meet defined quality standards, in line with the **EDTF's recommendations** that data should be discoverable, searchable and understandable. This will include publication of metadata about the data sets. We will provide powerful and logical search capabilities to support navigation. All our data will be available via an API and we will provide raw data for all visualisations or insights.

The data portal will also be a tool for sharing outputs of our enhanced data and modelling collaborations with other organisations.

Data security and privacy

While we will adopt a "presumed open" philosophy, we will remain a champion for data security and data privacy. We will remain vigilant to potential misuse of data that might threaten the system or distort markets. We will implement a transparent process for assessing any requirement for aggregation or anonymisation of datasets according to published criteria including:

- Consumer privacy – for example, personally identifiable information not publicly available
- Security – for example, the location of Critical National Infrastructure (CNI) assets/systems not otherwise generally visible directly or through other sources
- Commercially sensitive – for example, Capacity Market auction bid information
- Negative consumer impact – data that is likely to drive actions, intentional or otherwise, which will negatively impact consumers.

5.2 Transforming the customer experience through digital market enablement

ESO manages markets, industry processes and frameworks that in turn influence the efficiency of market outcomes. We believe there is great potential to improve the efficiency of energy markets through the application of digital technologies to enhance the customer experience of interacting with us.

[15] Open Government Licence - http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/

[16] Modernising Energy Data Programme - https://es.catapult.org.uk/impact/projects/modernising-energy-data-access/

Our customers and stakeholders currently have many touch points with us across activities such as participating in market processes, providing balancing services, understanding or changing industry frameworks, making connection applications or managing system access. We use a range of tools and channels for managing these interactions. Many include a mixture of email, offline spreadsheets, online forms and online platforms. Our proposals will streamline customer interactions with us across key services.

5.2.1 Strategic enablers to deliver digital market enablement

Single markets platform

We are implementing a number of actions now to enhance the service provider experience and reduce barriers to entry through digital market enablement technologies. For example, we have enabled online completion of pre-qualification and registration processes for wider access to the Balancing Mechanism.

Going forward, we will move an increasing number of customer-facing balancing services procurement processes online and in one place.

We are making it easier for all parties to sell services to us through the development of a Single Markets Platform. This one-stop-shop will provide a focal point for parties of 1 MW and above to participate in all our ESO balancing service markets. It will also provide access to the Capacity Market and the Contracts for Difference auctions.

The platform will interface with the data portal to provide both historical and forecast data to support market participants' investment cases and decision-making. We will expand the platform as other markets develop to allow the integration and data sharing required for efficient decisions across markets.

While our market platform will provide a route to participate in all ESO markets, service providers have impressed on us the importance of common standards with other flexibility platforms, particularly at the distribution level. We will work with DNOs and others to ensure that common standards, including interoperable systems, a common data model and shared minimum specifications are central to the design and delivery of the single markets platform. This interface will also allow the ESO and operators of the distribution system better visibility of what services are being provided to whom, as well as any network limitations on service provision.

The foundation of the platform will be an asset register identifying each unique asset on the transmission or distribution system that is participating in the markets. Participants will be able to manage their portfolio by aggregating assets from these underlying components to participate in the markets. We will seek opportunities to align further development of asset registers to support participation in ESO markets with **EDTF Recommendation 4: Coordination of asset registration**. We are planning to implement a consolidated asset register for generators and other assets participating in the Balancing Mechanism and Ancillary Services to underpin presumed Open Data sharing and net zero carbon operations. Some of the data held and used by ESO would be owned and mastered by external organisations, with some shared by/with other parties either directly or via ESO depending on the context. While these projects may resolve the issue of standardization across DNOs and centralising asset registration for all ESO services, they should address duplication between ESO and DSO, between DNOs, or for a multiple trading platform for any one DSO.

Many of our existing processes require service providers to use different methods and systems to register and take part in our balancing markets. This creates an administrative burden on both market participants and the ESO. Manual input also increases the risk of human error and associated rework. The markets platform will significantly reduce the time and effort required to participate in markets:

- Communications on processes including contracting, testing, procurement events, performance monitoring and reporting, payment and portfolio management will move from email to the portal. This will put all the relevant information in one place.
- Data input and management for processes including procurement events and performance monitoring will move from offline spreadsheets to data management and communication via the single markets platform.
- Messaging and validation rules will enable online decision support, for example by telling market participants which markets their assets are eligible for. The system will also notify them if they are submitting non-compliant information.

The market platform will significantly reduce overheads of market participation by streamlining the process, reducing manual input and checking, making market outcomes more efficient. Extensive stakeholder engagement has told us this will transform the experience and make participating much more efficient.

Fully digitalised whole system Grid Code

In the RIIO-2 period we will use digital technologies to make it easier to understand and manage industry frameworks and participate in the process to manage and modify them.

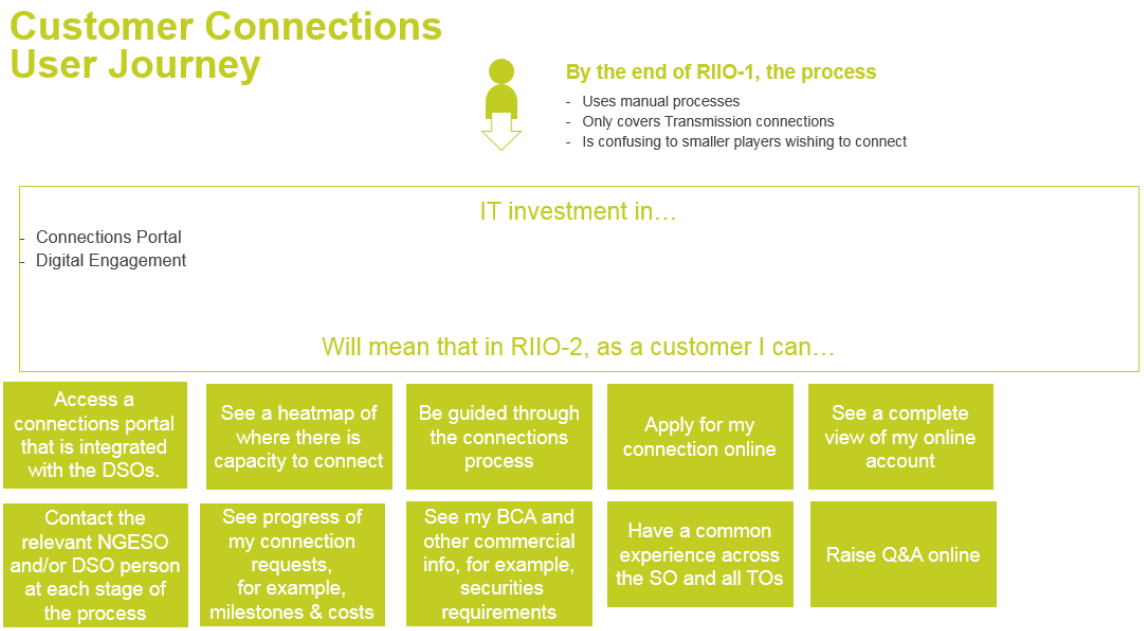
As part of our proposal to develop a single technical code for distribution and transmission we will use the latest data technologies to support navigation of the codes, tailored to each code user's individual needs. A more user-friendly and inclusive experience will better meet the diverse needs of our customers.

A whole system Grid Code that is easier to understand will increase the pace at which important decisions are taken throughout the connection journey. Crucially, it will provide more targeted and customised information as and when customers need it.

By making it easier to understand and navigate industry codes, we will also improve access for new, smaller entrants and encourage innovation in the market.

Connections Hub

As the ESO we play a central role in helping energy resources to connect to the GB electricity transmission system. To enhance our service provision, we will develop, in coordination with other network organisations, a connections hub that provides a seamless connections experience to customers. The connections hub will enable participants to access specific information on available network capacity as well as on-line account management. Being able to quickly understand where network capacity exists should help low carbon developers more quickly navigate the connections process. This will speed up the decarbonisation of the energy sector. The figure below illustrates our customer user journey established to inform the development of this activity



We will work with other network organisations to develop the connections hub. It will feature information provided by different parties as well as links to the appropriate network organisation for customers' needs whether they want to connect at the transmission or distribution level. Facilitating access to information across the whole electricity system will allow informed, efficient connection decisions, whether to connect to the transmission system or a distribution network.

Planning and outage data exchange

We facilitate efficient access to the network by Transmission Owners (TOs) and connected parties for maintenance and construction activities.

Customers, including generators and DNOs, are expecting increased levels of service both from us and TOs to minimise short-notice disruptions and to improve communication of any changes as ultimately this leads to additional cost. At the same time, more active distribution networks present opportunities for market-based solutions to system access.

To address our customers' needs and stimulate potential DER markets we will improve and extend our outage notification system. We believe there is value in extending our current advanced outage notification system (TOGA) to cover a wider range of stakeholders, with differing business models and needs. We will develop TOGA to offer a more interactive experience for customers, stakeholders and the market. This will include the use of mobile apps, alerts and other digitally-enabled technologies.

5.3 Pillar 2 - Build our core capability through digital technology

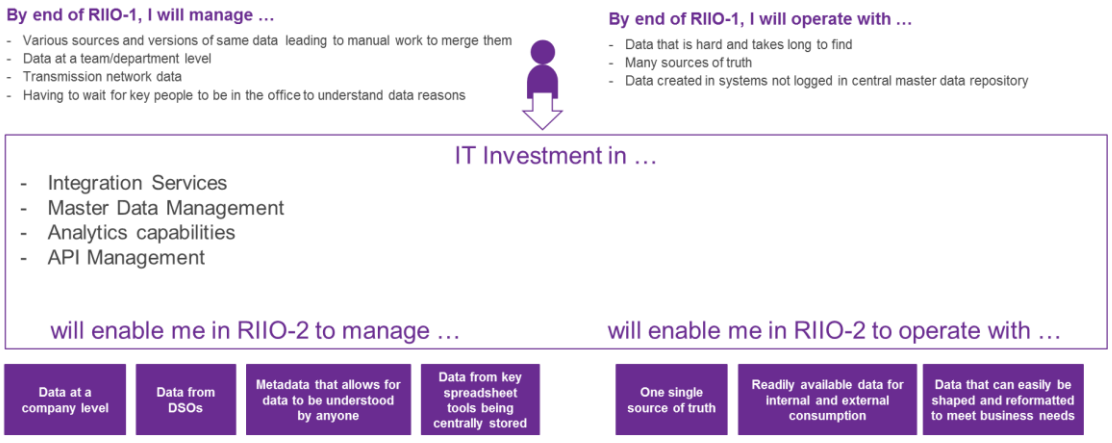
Consistent with **EDTF Recommendation 1: Digitalisation of the energy system**, we agree that more detailed, accurate and timely data will enable new operational paradigms and business models.

The changing energy system, including high proportions of renewable and distribution-connected generation and more active demand, brings with it challenges for planning and operating an efficient and secure electricity system. We believe the application of digital tools such as automation and AI to existing and new data to enhance capabilities across our business can help us to meet these challenges.

Supporting delivery of our digitalisation goals and the EDTF recommendations will require wholesale changes to our IT infrastructure. We will replace our internal data management systems with a new data and analytics platform that pulls together data from a variety of critical national infrastructure (CNI) and non-CNI sources. Our new underlying data management capability will be extensible, scalable and interoperable. The data and analytics platform will be a key enabler for all of the data rich activities across our organisation outlined in the following sections as well as our open data proposals described in the previous section.

The Data and Analytics Platform is a critical programme of work delivered as part of the RIIO-2 plan with almost all other investments dependent on it. It is anticipated that the volumes of data managed by the ESO will continue to increase significantly as a direct result of greater market participation. Closer coordination with DSOs will also increase the volume and types of data needed. This has prompted a need to develop solutions that can increase in scale and meet the increasing demands of our customers. The foundation of the ambition is built upon the premise of Open Data and data services being consistently available for internal and external stakeholders. The 5-year plan for the development of these platforms is underway and will align with the strategic data goals of the ESO.

Internally, this investment line will move all ESO data to a single platform and allow users to access it in the timescales they need. Externally, we will make available for consultation agreed sets of data. This will allow ESO customers to make quicker and more accurate decisions. They will be able to extract and feed the data into their own analytics tools. This single source of data approach requires a rigorous and well managed process and culture. It also requires our infrastructure investment to support this increase in capability. To make the data accessible across the whole ESO we will invest in the required integration layer and associated APIs. The user journey established to inform our development of this platform is set out below.



The data and analytics platform will retire many of our data legacy systems. It will include analytics capability, so we can access, share and shape any type of data we store. This is critical to allow quicker, accurate operational decisions and give our customers value added information.

The major uses of this platform and enablers to delivering our digitalisation strategy are:

- Energy forecasting
- Balancing and control
- Digital twin technology
- Market data
- Market simulation and analysis
- Network modelling
- Modelling and data exchange for whole system operability
- Energy system data and analysis

The following sections summarise these under the strategic themes we employed in our RIIO-2 business plan.

5.3.1 Strategic enablers to build digital technology capabilities

Theme 1 - Reliable, secure system operation, to deliver electricity when consumers need it

Energy forecasting

Our forecasts contribute to the decision making of market participants through operational and pricing decisions delivering better functioning markets. Better forecasts with less uncertainty also benefit consumers, as less uncertainty means our control centre needs to hold fewer balancing services in reserve, resulting in lower spend on response and reserve services.

We are using modern digital technology to build a new platform for energy forecasting (PEF) to replace our current forecasting system. By March 2020 this will result in enhanced demand, wind and solar forecasts.

There are four digital enablers to this:

- Data management – implementing effective management, control and governance to create and maintain a trusted data set on which forecasting models, operations, the market and reporting can rely on.
- Reporting and analytics – data exploration and KPI reporting, embedding insights into operations and for market participants.
- Modelling and automation – wide enablement of automation and advanced modelling technologies, including machine learning, to streamline operations and deliver ongoing, sustainable improvements. To give an order of magnitude, the current estimate is that when wider access to the Balancing Mechanism comes in, we anticipate training in the order of 100,000 concurrent models daily which represents several orders of magnitude increase from the present day.
- Operational support and modelling – round-the-clock support, maintenance and troubleshooting for data capabilities, ensuring system stability, robustness and compliance with Grid Code and licence obligations.

Enhancing these capabilities has already led to a 12% improvement in our day-ahead demand forecasting. Further enhancements will substantially increase the number of forecasts we provide, including 24 daily demand, wind and solar forecasts.

Through our innovation projects in collaboration with the Alan Turing Institute and Sheffield Solar (part of the University of Sheffield), we have delivered a 33% improvement in solar forecasting. This has been through new advanced modelling capabilities and more accurate data.

We worked with the Alan Turing Institute to create a new ‘random forest’ approach to analyse 80 input variables, instead of just two we used previously. The random forest uses machine learning to train itself to find hundreds of different mathematical pathways (or decision trees) to arrive at an output generation figure.

We then combined this with enhanced solar PV forecasts, developed with Sheffield Solar. These were produced by combining accurate generation data from a sample of solar PV systems and using advanced statistical models to scale that to a national level.

Balancing and control

We are conducting foundational work to ensure our current systems can manage an increasing number of market participants, both as the market decentralises and from external initiatives such as wider access to the Balancing Mechanism.

We are working with the Smith Institute to update the modelling capabilities in our current Balancing Mechanism dispatch tool. This involves rewriting the algorithms in modern coding language and boosting the computing power to allow it to consider more variables and give a better solution.

We are also updating the API modules to allow more participants to communicate with our systems. We will move from hardwired point-to-point communication, which is cost prohibitive for many smaller parties, to web-based communication systems that can be scaled easily.

Moving towards the RIIO-2 period we will see a step change in our application of new data and digital technologies; enhancing our capabilities and enabling secure operation of a zero-carbon electricity system.

Building on strategic design work and inertia forecasting and modelling in RIIO-1, automation, machine learning and AI will enable us to handle greater volumes of incoming data and balancing actions. We will be able to schedule and dispatch very high volumes of renewable and distributed generation. More efficient balance of supply and demand will minimise the costs of operating the system and bring benefits to consumers.

We will develop new online and offline modelling capabilities, including whole electricity system simulation and modelling aided by machine learning and probabilistic analysis. This enhanced look-ahead capability will allow us to predict transmission problems in a more volatile operating environment and take actions ahead of real-time to reduce cost. New situational awareness tools and upgrades to our control centre video walls and operator consoles will allow us to visualise and analyse more operational data. This will give us a better understanding of the 'operating envelope' and mean we can optimise decisions to run a more efficient system safely and at lower cost to consumers

Digital twin technology

We will use simulation and hypothesis testing using digital twin technology to enhance the way we develop our new balancing and control tools, which will then be built offline in a modular and agile way. In a cultural shift, we will move away from large tools and IT systems, where the algorithms, data and control centre user interface sit together, to smaller tools that only house the system algorithms, with data sitting on the central data and analytics platform with the interface bundled up. This benefits future energy consumers, by making it easier for us to upgrade tools in the future as we will only need to amend the algorithms.

Our use of digital twin technology is aligned to the vision for the UK national digital twin (NDT). We will consider how to engage with stakeholders, such as via the Centre for Digital Built Britain Digital Twin Hub[17]. This aims to create a federation of digital twins and could bring huge benefits for system operation. For example, connecting a digital twin of our electricity system balancing tools to those that model electric vehicles (EVs) could help us better understand the challenges and opportunities from increased EV uptake.

The digital twin technology will be aligned to the Gemini Principles[18], which guide the development of the NDT:

- Must have clear purpose: our digital twin technology will help inform the development of our new balancing and control tools and help the ESO make better operational decisions. It unlocks consumer benefits as we set out in us RIIO-2 cost-benefit analysis[19]
- Must be trustworthy: the digital twin technology will create replicas of our critical national infrastructure (CNI) systems and will be subject to the appropriate levels of security. We will work with industry, in particular TOs and DNOs, to run joint training and simulation exercises using our digital twin technology and replicas of their own assets to facilitate increased whole system thinking and training.
- Must function effectively: using digital twin technology in a modular fashion as we develop our new balancing and control capabilities, means we will remain agile, able to adapt as technology and society evolve. Having flexibility will be a key enabler to meeting the UK's net zero ambition by allowing us to take advantage of new services, technologies and thinking that can support decarbonisation

Theme 2 – Transforming participation in smart and sustainable markets

Market Data

[17] Centre for Digital Built Britain Digital Twin Hub - https://www.cdbb.cam.ac.uk/DFTG/NDTHub

[18] Centre for a Digital Built Britain – Gemini Principles https://www.cdbb.cam.ac.uk/DFTG/GeminiPrinciples

[19] RIIO-2 CBA Annex - https://www.nationalgrideso.com/document/158061/download

We have been working to better understand our data needs to facilitate new markets and gain access to insightful data.

We are working with UK Power Networks, SP Energy Networks and Electron to develop and demonstrate an asset register for energy resources. The RecorDER project[20] seeks to define, assess and pilot a blockchain-based asset register, enabling parties to use a shared data set of generation and flexibility resources. This project will help us to understand whether a shared asset register for flexibility assets will enhance whole-electricity-system visibility, data quality and accuracy, ultimately facilitating easier trading of assets across transmission and distribution. This project is supportive of the **EDTF Recommendation 4: Coordination of asset registration.**

As residential energy users and producers become more active, we need to understand their evolving characteristics and potential contribution to balancing markets. The Residential Response project[21] is developing new approaches for testing, monitoring and managing portfolios of residential-scale assets for participation in ESO balancing services.

Fit-for-purpose procedures for data capture and performance measurements are essential for wider participation in balancing services markets. The project will determine procedures for data capture and options for measuring power and frequency from large portfolios.

Market simulation and analysis

As we move through the RIIO-2 period we will increasingly apply new sources of data and advanced modelling tools to simulate market behaviour.

We will enhance our balancing market simulation capability through trialling potential solutions in an experimental market sandbox environment. Our current analogue systems mean we currently trial new approaches through integration and testing with operational systems, making us risk-averse. In future, we will build digital replicas, using live data in an offline environment, allowing us to safely test new approaches, learn-by-doing and driving continuous improvement. This will allow scope for further iterations, benefitting future energy consumers.

To improve our security of supply modelling capability, ensuring we have the capacity we need in the future low carbon, more decentralised world, we will develop new data sets, models and methods to model; the growing interactions of non-conventional plants; the contribution from new combinations of technologies, e.g. co-located hybrid sites where there is connection limitation; and, with growing interconnection across Europe and GB, interactions of future plant mixes and operational regimes across Europe

Theme 3 – Unlocking consumer value through competition

Network modelling

We are establishing new, more efficient ways to undertake more complex analysis and assess the growing number of interactions between different network issues. Through innovation projects, we are exploring ways to improve our modelling techniques to enhance our analysis and decision-making.

We are working with Strathclyde University to investigate the possibility of a new voltage assessment tool that can examine more scenarios, more quickly. If this proof of academic concept is successful, a new voltage-optimisation tool will be developed. We are keen to integrate this with other tools to allow us to look across a range of system needs at the same time, such as thermal, dynamic and steady-state voltage requirements.

We will also integrate our economic-assessment tools with our power-system modelling tools, building in the processing power to solve ever more complicated network optimisations.

Subject to the success of our probabilistic modelling and voltage optimisation developments, from 2024 we will provide an online portal for stakeholders to see a visual representation of network needs and to potentially test high-level solutions. Our work in this area will support the delivery of **EDTF Recommendation 5: Visibility of infrastructure and assets and the Digital System Map.**

Theme 4 – Driving towards a sustainable, whole energy future

Modelling and data exchange for whole system operability

[20] RecorDER project - https://www.smarternetworks.org/project/NIA_NGSO0018

[21] Residential Response project https://www.smarternetworks.org/project/nia_ngso0025

We are supporting cross-industry efforts to enhance data sharing and collaboration. One example is the Energy Networks Association (ENA) Open Networks project proposal to build on the current Grid Code data requirements to exchange more granular information on distribution networks and distributed energy resources (DER). This data will help us more efficiently identify future transmission system needs and support timely connection of DER through the Statement of Works process. This is just the first step; more granular data can help us work with other network organisations to efficiently manage an increasingly decentralised grid. This work is supportive of the **Modernising Energy Data Programme**[22].

Our increasingly probabilistic approach to modelling will help to accelerate scenario planning, including closer-to-real-time. We are also investigating the use of AI and automation to enable improvements in modelling.

We are also applying learnings from innovation projects to enhance our future operability analysis and planning including:

- Enhanced Frequency Control Capability (EFCC)[23] project to enhance visibility of frequency data at a regional level and facilitate the participation of demand side response (DSR) providers in balancing markets.
- Investigation & Modelling of Fast Frequency Phenomena[24] project which will gather detailed information on frequency fluctuations from PMUs (Phasor Measurement Units) and develop a visualisation approach for overlaying the data on the GB power system. The project will also explore and evaluate whether current power system modelling software can comprehensively explain the observed phenomena and make recommendations for any improvements to the ESO's data, models or processes.

Energy system data and analysis

Our ability to provide insight to inform whole energy system policy is built on data-driven analysis, including data from our innovation projects including:

- The Network Innovation Allowance (NIA) project on Electric Vehicle's (EV) charging behaviour[25], which has brought a step change in our modelling of electricity demand from EVs.
- Our self-funded carbon intensity forecasting project[26], which uses machine learning and automation to provide more accurate forecasts. We publish these forecasts to enable consumers, academics and industry stakeholders to make more informed choices, and ultimately move the industry towards optimising the use of renewable electricity.

In future we will increase our collaboration with DNOs and a wider range of stakeholders to inform our insight on whole energy system policy. We will develop more granular models, both geographical and temporal, and incorporate increasing volumes of data, such as from smart meters. This includes developing local models with DNOs and gas distribution networks covering the whole year, not just at times of peak demand. Modelling along the demand curve allows us to better reflect how it may change due to increasing solar power and use of electric vehicles. We will also support DNOs to develop their regional FES by aligning our energy data capture, analysis and modelling processes.

We will continue to enhance our data capture and capabilities, including delivering modelling improvements such as a spatial heat model[27]. This innovation project will enable a more regional approach to be employed to understand the locational impact of heat decarbonisation. This improved evidence base will allow better network planning outcomes and faster adoption of optimised decarbonisation solutions across gas and electricity systems. Our work in this area will support the delivery of **EDTF Recommendation 5: Visibility of infrastructure and assets** and the Digital System Map.

[22] Modernising Energy Data Programme - https://es.catapult.org.uk/impact/projects/modernising-energy-data-access/
[23] Enhanced Frequency Control Capability project - https://www.smarternetworks.org/project/ngeten03
[24] Investigation & Modelling of Fast Frequency Phenomena - https://www.smarternetworks.org/project/NIA_NGSO0007
[25] EVs' charging behaviour - https://www.smarternetworks.org/project/nia_ngso0021
[26] Carbon intensity forecasting - https://carbonintensity.org.uk/
[27] Spatial heat model - https://www.smarternetworks.org/project/nia_nggt0154

5.4 Pillar 3 - Transform our organisational culture and digital ways of working

To achieve our digital ambitions, we will have to transform our organisation's capabilities, culture and ways of working. We want to drive in-depth transformational change across the piece.

While we want to take the time to get this strategic piece right, we are also keen to start transforming our organisation as early as possible and do not want to wait until we have the perfect plan to act. Therefore, we are also seizing every opportunity we can to transform our capabilities, culture and ways of working, ensuring that the actions we take now are decisions that we will not regret. Those actions are detailed in the action plan.

Transforming our organisation so that it is and feels digital will require us to:

- Transform the way we **resource and retain** talent that is core to our business needs
- Develop key **capabilities** around data management, data analytics and change
- Further develop our **culture** to be even more collaborative, agile and generally innovative
- Transform our **ways of working** to bring the digital aspects of our culture to life

The above points are explored below.

5.4.1 Transform the way we resource and retain talent that is core to our business needs

- Leverage our central role in the energy transition to retain and attract new talent
- Develop a more diverse, digitally native workforce through training and recruitment
- Maintain our strategic workforce planning to identify and address capability gaps

In the ESO, we consider our people to be our most important asset. And we believe that building a diverse and flexible workforce is the key to success in RIIO-2.

In order to address the step-change in headcount and capabilities that we need to make in preparation for RIIO-2, we have created a **People & Capability team** which has been working to identify and mitigate against future workforce and capability gaps. The ESO will be using a blended sourcing strategy to fill the gaps identified by the team. This means we will continue to invest in training our existing workforce and building capability identified through employee development plans and capability diagnostics. We will also continue to 'grow our own' workforce for critical roles through our successful trainee intake; building a pipeline of resource and future capability. This will be supplemented by external direct hires to fill new and specialist roles through both permanent and contractor hires. Examples of our actions are included in our action plan.

We are also planning to review the way we resource our activities, particularly in a world where the work we undertake, or are asked to take on, can change rapidly. We need to set ourselves up in a way where we resource new activities that come up or existing activities that take up more resources than expected, at pace. We will review our internal resourcing arrangements, as many activities will require capabilities that come from very different teams and with variable work levels and time commitments.

One of the key areas of focus of our People & Capability team in the autumn of 2020 is leading a recruitment campaign for the ESO that will fill a significant number of the new positions we know we need in RIIO-2. We are doing this in phases, to allow us to build some flexibility in the process (and focus on the high-priority roles first) while also allowing the teams to onboard the new recruits in an appropriate way.

Another area of focus for the People & Capability team is to work on developing our pipeline of talent for some of our core capabilities, and particularly for the core capabilities that are going to be needed across the ESO. As an example, we are re-focusing parts of our New Talent strategy so that it targets profiles that we know we are going to need in the ESO.

We have also engaged with Loughborough College and University over the past few months and have taken the decision to support them as well as their partners in their bid to create a new Institute of Technology. This bid was handed in to the government mid-December 2020 and we proposed to be an anchor partner in this initiative. Our role in this initiative is to help shape the strategy of the Institute of Technology so that it builds the net zero and digital workforce of the future in an innovative and enduring way.

Overall, we believe we have a strong employee proposition that will help us attract talent in the business. Our mission is to enable the transformation to a sustainable energy system and ensure the delivery of reliable, affordable energy for all consumers. This exciting employee proposition helps us attract and retain new talent. Our employees have a strong purpose as they can anchor their contribution to the energy transformation at such an exciting time.

Two facets of our recruitment approach will drive us towards an employee base increasingly made up of 'digital natives': our ongoing intake of talent through our graduate programme tends to bring in younger, digitally-aware employees; direct hires are often recruited in areas where we are seeking to enhance our digital capabilities and skills base, such as data analytics and IT delivery. These individuals by nature of their age and/or professional inclination are more likely to be digitally confident. The ongoing influx of digitally-confident staff will further embed and promote the digitally-enabled processes and culture we are seeking. Further details of our how we will attract and retain talent can be found in chapter 14 People, culture and capability in our RIIO-2 business plan[28].

5.4.2 Develop key capabilities around data management, data analytics and change

- Strengthen our data analytics and data management capabilities
- Strengthen our change management capability, particularly in relation to our IT change projects

From a digital perspective, we will upskill our workforce across several key capabilities to ensure that we are able to use more data in a better way and deliver the change projects that are a core component of our digital transformation. Whilst power system engineering and commercial services will remain at the core of our organisation, data analytics and management, as well as stakeholder engagement and change management will be increasingly important.

This will require a significant shift in capability to bring us closer to more digitally mature industries. This shift is crucial to establishing the future services and datasets our customers will need and is also central to the successful delivery of our digitalisation strategy

Since submitting our RIIO-2 Business Plan and Digitalisation Strategy in December 2019, we have already taken a significant number of actions to help us understand the size of the shift that we need to make:

- Starting from the necessary high-level capability shifts that were highlighted in our plan, we designed our ESO capability framework, and have used it as our structure for the rest of our work;
- We then used this framework to assess the capability requirements of the teams across the business, and to ask the business to complete a workforce proficiency assessment
- We are now finalising a gap assessment between the two above outputs, which will give us an understanding of the size of the gap we need to fill

We need to strengthen our data analytics and data management capabilities

We will use data to provide rapid and automated predictive insights, providing value for system operation and market participants. This includes data analysis, modelling and programming capabilities, sometimes working with machine learning algorithms and AI. When combined with knowledge of statistics and neural networks this will improve our use of data throughout the timescales in which we operate.

Transforming the business into a data-driven business will require in-depth change. We already have pockets of data analytics and data management expertise across the business today, but we feel we need to bring them together and build on that community to drive a proper change in the ESO. How we do this is something that we are still exploring as a part of our strategy work.

We need to strengthen our change management capability, particularly in relation to our IT projects

We need to be able to deliver cross-business and cross-industry change projects iteratively, incrementally, to high standards, on time and within budget that deliver high levels of complexity, operational need and level of dependency across the industry; interface with large IT transformation programmes; translate business requirements into IT technical requirements and vice-versa. This capability will require a culture shift towards more agility, flexibility and ability to absorb change.

- **Change management** – our objective is to develop our in-house change management capability to ensure we can deliver its transformational projects. This will be done in addition to increasing our access to change management capacity through our shared services model with National Grid UK.
- **IT systems change, delivery and integration** – our objective is to develop this capability significantly, to be able to build and deliver the data- and digital-heavy transformational IT systems that we have included in our business plan.

Details on the actions that we have taken and are planning to take are included in our action plan.

[28] ESO RIIO-2 Business Plan - https://www.nationalgrideso.com/document/158051/download

5.4.3 A collaborative, innovative and agile culture

- Ensure clear, value aligned workforce and delivery partner engagement
- Establish an enterprise, collaborative mindset and cross-ESO processes
- Operate with agility and flexibility, and greater stakeholder engagement

To achieve our digital ambitions, we will transform our business and take our employees along a continually evolving change journey and adapt our organisational culture. We are planning key behavioural shifts, in line with our core values. These behaviours will be reflected and reinforced across all elements of our business to ensure everything, including leadership tone and governance, aligns to our desired culture. The table below sets out our values and the behaviours we expect our people to demonstrate and those we look for when we recruit.

Values	Behaviours
Do the Right Thing	Care about **our mission**, whether it's the operational aspect of 'keeping the lights on' for Great Britain or the environmental drive towards net zero – or both!
	Believe that **diversity** of backgrounds and opinions create better solutions and will go out of their way to make sure that each engagement opportunity is diverse and inclusive.
Make it Happen	Care about delivering excellent **customer service** and making sure they and their teams make anyone's experience of working with the ESO a great one.
	Are excited about **change** and with shaping and delivering **fast-paced** projects, in a world where the ESO's responsibilities are evolving as rapidly as the energy landscape is.
	Lead their teams to **grow** and **evolve** along with how the ESO itself is growing and evolving, to deliver what Great Britain needs.
Find a Better Way	Believe that **collaboration** and good **communication** drive better results and will work together with colleagues, customers, stakeholders and consumers to deliver projects at a high standard
	Guiding their teams into **challenging** the status quo by **improving** processes and experiences and using new tools and techniques to do so.

The Y and Z generation, who have grown up in a connected, collaborative and mobile world, will account for over half of our workforce before the end of the RIIO-2 period. This change in workforce balance will redefine corporate culture and drive us to do things differently, such as greater use of mobile technologies. Our systems will support **flexible working**, a more open and social approach to collaboration that is increasingly automated, intelligent and very data centric.

We will improve employee engagement by providing our people with the tools they need to do their job efficiently and effectively meet their customers' expectations. Unified **communications and collaboration** tools will increasingly support collaborative working objectives and improve productivity and employees' ability to collaborate remotely and reduce travel. We are already moving from spreadsheet-enabled working processes to robotic process automation.

We will provide better tools and processes for our people, so that they are able to provide more **value-added services** to our customers and stakeholders, in support of our strategic pillar to transform the customer experience through digital market enablement. With the rapid development of technology services such as augmented reality, automation, and intelligent algorithms, we expect opportunities will emerge through the RIIO-2 period that we can use to further improve **productivity** and make **efficiency** savings.

5.4.4 Transform our ways of working to bring the digital aspects of our culture to life

- Phased digital project delivery, whilst maintaining integrity of existing critical systems
- Deploy pilot projects with high consumer value to prove out and then scale
- Adopt a structured approach to identify and prioritise further opportunities

It is essential that we deliver digital projects whilst maintaining and protecting the integrity and security of critical existing systems and ongoing projects. It would be a high-risk approach to attempt to deliver digital transformation across our whole business with a 'big bang' philosophy. We are adopting a phased approach to digital transformation. As outlined in Pillar 1 - Delivering open data and digital market enablement and Pillar 2 - Transforming our core capabilities we are already deploying pilot projects in areas with high potential for consumer value creation, such as energy forecasting. Through these projects we will develop our understanding of the potential of digital technologies, as well as what works and what does not. We will adopt a structured approach to identifying opportunities across our business. Developing our data and analytics and

IT delivery capabilities will support the structured delivery phase of digitalisation roll-out to a wide range of activities.

The increasing pace of change and increasing need for transparency and collaboration across various players in the industry has meant that the ESO has already had to find new ways of working internally and externally, also adapting to the ways that other players in the industry wanted to work with us. We still have a lot of ground to cover before we are at the point where we can say we have a digital culture and ways of working, but those new ways of working have brought us one step closer:

We will continue to employ an **agile approach** to the services we develop and projects we complete, working with a collaborative mindset to rapidly build and implement cross-ESO processes in order to deliver significant consumer benefit. This approach is inherent in how we work at present; recent examples of successful delivery with this approach, outlined in more detail in the 2020-21 Mid-Year Report[29] , include:

- Optional Downward Flexibility Management (ODFM) - optional balancing service introduced over summer 2020 to meet operational challenges resulting from low demands due to Covid-19; designed at pace as a whole system solution with DNOs,
- Dynamic Containment - first in new suite of frequency response products, working closely with market providers to develop design parameters leading to successfully launching the product,
- Pathfinders – as series of procurement activities to establish competitive market solutions to complex network engineering challenges, bringing together multiple disciplines within ESO as part of "virtual teams" to deliver the end-to-end tender processes.

We also currently employing formal agile methodologies to support delivery of major programmes, such as in balancing services and network control.

We have been using, and will extend the use of, our **collaborative tools** (e.g. Obeya and virtual teams) to run projects that require the input and ownership of several teams across and beyond the ESO, e.g. to lead the development of a tool for whole-system cost-benefit analysis within the ENA Open Networks project; and internally, using the Obeya collaborative tool as a supporting structure for recent major collaboration and high-impact projects, e.g. for our Operability and RIIO-2 work.

One of the ways that we are considering encouraging internal collaboration across teams, is to set up **Communities of Practice** (CoP) where it makes sense to do so. There are currently two CoPs in the ESO and both are directly relevant to our digital transformation: data management and advanced analytics (modelling). Over 100 ESO people are members of the data management CoP, predominantly as data stewards and practitioners. These CoPs have been established to identify the areas of the ESO where those capabilities were sitting; the specific skills the members of these communities have; to share best practices, educate and upskill others; and to provide ad hoc (small) project support.

They are not resourcing pools. And there is scope for those CoPs to be further developed if it is decided that they can do more to drive our digital transformation, along with the creation of other CoPs, like a CoP for change management (which we are currently exploring).

Externally, we also drove immense value from the co-creation of our RIIO-2 business plan through regular **engagement** with many of our industry stakeholders, and in particularly from our regular engagement with the **ESO RIIO-2 Stakeholder Group** (ERSG), which we used to challenge our thinking with a strong group of c. 20 senior stakeholders from across the energy industry. This structured and focused approach ensured we had a regular opportunity to present our plans to be challenged and improved, ensuring they were robust and would meet Ofgem's expectations.

[29] ODFM p13/14, DC p57/58, Pathfinders p85/86 - https://www.nationalgrideso.com/document/178351/download

5.4.5 Attracting, retaining and enhancing our workforce

- Leverage our central role in the energy transition to retain and attract new talent
- Develop a more diverse, digitally native workforce through training and recruitment
- Maintain our strategic workforce planning to identify and address capability gaps

Our people are our most important asset. Delivering our strategic intent will require significant upgrading of our capabilities in certain core talent areas. We have identified gaps in capability and capacity and are confident we can fill them with a blended sourcing strategy. Our unique people value proposition will be a key asset. Our mission is to enable the transformation to a sustainable energy system and ensure the delivery of reliable, affordable energy for all consumers. This exciting employee proposition helps us attract and retain new talent. Our employees have a strong purpose as they can anchor their contribution to the energy transformation at such an exciting time.

Our proactive strategic workforce planning has meant that we can identify and mitigate against future workforce and capability gaps. We will be using a blended sourcing strategy to fill the gaps. This means we will continue to 'grow our own' workforce for critical roles through our successful trainee intake; building a pipeline of resource and future capability. We will continue to invest in training our existing workforce and building capability identified through employee development plans and capability diagnostics. This will be supplemented by external direct hires to fill new and specialist roles. We will recruit a diverse workforce from across and beyond our industry.

We are working with universities to create the modules required and educational pathways to create the pipeline of data scientists we and the wider industry require and broaden the skills of our core Power System Engineering resources. We are also working with DNO's, sharing data to enable easier comparison of our Future Energy Scenarios (FES)[30] with the Distributed FES, published by DNOs.

We will review the way we resource our activities, particularly in a world where the work we undertake, or are asked to take on, can change rapidly. We need to set ourselves up in a way where we resource new activities that come up or existing activities that take up more resources than expected, at pace. We will review our internal resourcing arrangements, as many activities will require capabilities that come from very different teams and with variable work levels and time commitments.

As the pace of change in the industry creates the need for us to take on new activities at pace, and our workforce is made out of millennials who tend to change roles more often, we cannot afford to rely only on traditional external recruitment methods where it takes 3 months to find someone on the labour market, select them and bring them into the business (at a bare minimum – it is more around 8-9 months for Power Systems Engineers).

A further part of the blended sourcing strategy includes exploring other options to secure the right data and digital resources we need. The options include establishing where it makes sense to fill positions with contractors or permanent hires, engaging with organisations who can help us accelerate this process; forming partnership arrangements to supplement in house capabilities (such as data analytics and power systems engineering), giving access to best practice, market leading skills. We will also increase our comms and refresh our employee proposition so that the ESO is seen and considered as an attractive place to work, in the labour market.

6. Embedding data and digital practices

6.1 Data management

Our data management policy is consistent with the principle of 'presumed open'. To ensure we are open and transparent about the data we use and share we will ensure that we:

- have a complete inventory of all of our business-critical data
- assess all of our data for criticality and confidentiality
- implement publication controls, to ensure we send the right data to the right people at the right time
- challenge current approaches to what data can/can't be shared

To enable this, we will implement a Master Data Management Solution (MDM) to manage shared data, in order that organisational goals are met, risks associated with data redundancy are reduced, higher data

[30] ESO Future Energy Scenarios (FES) - https://www.nationalgrideso.com/future-energy/future-energy-scenarios

quality is ensure, and consequently there is a reduction in the cost of data integration. The MDM will enable us to:

- Enable sharing of information both inside and outside of the ESO
- Provide authoritative sources of reconciled and quality-assessed master and referenced data
- Lower cost and complexity through the use of standards, common data models and integration patterns

We will also implement Data Quality Management tools and techniques in order to:

- Develop a governed approach to make data fit for purpose, based on consumers' requirements
- Define standards, requirements, and specifications for data quality controls as part of the data lifecycle
- Define and implement processes to measure, monitor, and report on data quality levels
- Identify and advocate for opportunities to improve the quality of data, through process and system improvements

We continue to mature as a data enabled services organisation; applying the data management standards we have established over the last three years and that we continue to enhance. Our standards follow the Data Management Disciplines of the Data Management Association (DAMA), summarised below and explained in their Data Management Body of Knowledge[31].

1. & 2. our data is valued as an asset and managed, protected and appropriately exploited throughout its lifecycle. We ensure data is governed, assured and secure from unauthorised access with ownership and other key organisational roles and responsibilities clearly defined.

3. & 4. we unlock the value inherent in our data. Our data does not need to be perfect, but it must be fit for purpose, in terms of conforming to clearly defined quality characteristics. Our data also becomes inherently more valuable when it is made available in standardised formats and linkable to other data sources

5. we re-use of data with a single authoritative (master) source of data

6. & 7. we provide transparency by opening up appropriate access to accurate and complete data to both our internal and external data users / stakeholders

We have designed our Data Management BMS (Business Management Standard) to ensure these principles are adopted. Ensuring we maintain our data quality (accuracy and completeness), effective governance and can mandate their application throughout ESO, including when enhancing and developing new services for our customers and wider stakeholders.

By implementing these Data Management standards, we are supporting the delivery of the following Energy Data Taskforce (EDTF) recommendations:

- **Digitalisation of the energy system** – Improving the data culture and capability of the ESO
- **Maximising the value of our data** – Deriving insights from our data to drive business improvement activities
- **Visibility of data** - Reviewing and implementing the right controls to ensure our data is accessible to those that need it

A summary of our actions, supporting delivery of all the EDTF recommendations, are set out in Appendix 2.

[31] DAMA Body of Knowledge - https://www.dama.org/cpages/body-of-knowledge

In order to move further towards a culture of 'presumed open' we have established data standards, including:

- Assigning publishing owners for all our data
- Confirming the use of verifiable sources for data we publish
- Validating format and quality for data prior to release

These standards ensure we continuously seek to improve our stakeholders service delivery experience and increase the amount of data they can access, ensuring it is open to all as soon as it is appropriate. Our internal data users also benefit from this through increased operational efficiency, reduced risk of non-compliance, better decision making and efficient management of growing data volumes.

In order to continuously improve our data standards, in all business areas, we will maintain our central Data Assurance and Governance team. Their main purpose is to ensure effective data management, drive continuous improvement and greater data maturity.

We operate a 3 lines of defence model in the ESO. The 1st line (ESO business teams) can use measures provided to identify and remediate any gaps and assess their own control opinions. Our 2nd line assurance team (ESO Assurance) audit against the data management standards we have defined using gap analysis to drive remediation actions. The 3rd Line (National Grid Group Assurance) ensure that we are appropriately adhering to data management standards and are utilising insights to drive our assurance and improvement activities.

We have introduced a number of data management roles across the ESO, to ensure that data governance is managed at a local level, as well as supported centrally.

- The **Data Owner** holds statutory and/or business authority for the specified data, is aware of how it is used, by whom, and owns the business risk associated with it.
- **Data Stewards** are responsible for good data management within their business processes, delegating to data practitioners where required and monitoring and reporting data quality and governance.
- **Data Practitioners** all have personal responsibility for data quality, reporting data issues and practicing good data management.

To achieve, regularly assess and evidence adherence to these standards we have created and manage a Data Management Library (DML). This securely holds all data relating to the ESO's systems and information flows, both internal and external; providing a view of our data landscape. All references of our business-critical data (both internal and external) are held within this library and ensure all data:

- has an owner and a data steward
- is assessed for criticality and confidentiality
- has sources and destinations captured
- has appropriate controls implemented and evidenced
- is assessed for data quality

The metadata held within the DML is in line with the Dublin Core Metadata Element Set.[32]

These standards have enabled us to ensure we are 'in-control' of our data. We will now focus on improving our data management capabilities and data minded culture by:

- Ensuring we have people who have the right skills and capability to pro-actively drive continuous improvement around how we manage, share and use date
- Providing suitable tools and technology that enable ongoing optimisation of our data and data management related processes

We have embedded data management as a core capability across ESO and through the services we offer and develop, we will continue to focus on increasing our data quality, maturity and openness to enable realisation of our Digitalisation Strategy.

To further increase our data maturity and reduce risk we are implementing and, by April 2021, will be compliant with two new data management standards. The external publication control standard will further support the principle of 'presumed open', as illustrated below.

External publication control
• Comply with external obligations to publish data (Legal, Regulatory, Licence or Code) • Ensure appropriate use of data i.e. maintaining confidentiality • Provide quality assurance on any released data • Establish appropriate release controls

[32] Dublin Core Metadata Element Set - http://dublincore.org/

- Meet stakeholder expectations
- Avoid incidents

We will also continue to invest in becoming a more data enabled, digitalised service delivery organisation through:

- increasing data access to create additional value through its wider exploitation
- comprehensive awareness and adoption of our data principles and standards across all levels and areas of ESO
- embedding and optimising our data tools, resources and frameworks
- Creating broader data related business processes
- Establishing forward looking metrics to drive further data management improvements.

6.2 Agile framework

We are continuing to develop how we design our services for our customers and wider stakeholders. This includes the application of agile methodologies, to enable us to deliver new services and so benefit customers faster. We have reviewed the UK Government's centre of excellence, Government Digital Service (GDS) manual and see that it sets standards and guidance that align with the practices and frameworks we are adopting from the Scaled Agile Framework - SAFe 5.0.

We are adopting SAFe, to enable our design of data and digital services, as it is more comprehensive than the GDS standard, going beyond the principles of design in GDS, giving guidance and methods across how the standards are adhered to and how people and processes should be structured for success. It provides industry recognised practices, methods, training and certification for agile design and delivery covering Business and IT roles and responsibilities, with customer outcome and needs driving the practices and standards, which is critical to the successful adoption of digital services and outcomes.

We are already training our teams in SAFe methods, with SAFe certification undertaken as part of the training process. We have started to assess how we align our internal business and IT practices and processes to further align with SAFe.

6.3 Cyber security

Cyber security plays an integral role in the solution delivery lifecycle for all projects we undertake. Engagement with the National Grid Security team is baked into the solution delivery framework for projects and this ensures that security is included throughout all necessary elements of solution delivery, including across both agile and waterfall delivery methodologies. National Grid Security have also developed an IT control set which aligns to numerous standards, including: NIS-D, NIST, ISO27001 and PCI-DSS. Our IT Risk team work with projects to identify applicable controls from the framework depending on the scope of the delivery.

These controls are also validated by our assurance function at the end of the project delivery lifecycle. A set of baseline security requirements, which are applied across all projects, are used to ensure secure delivery of solutions. These baseline security requirements are mapped to our IT control set and ensure relevant security controls are applied and validated. In addition, security consultants work with projects to identify additional requirements and controls above the baseline security requirements. We also work regularly with the National Cyber Security Centre[33] to review architecture and controls for key critical projects.

[33] National Cyber Security Centre - https://www.ncsc.gov.uk/

7 Cost benefit and decarbonisation

To explain the costs and benefits of our planned data and digital related activities we have set them out below against pillars 1 and 2 respectively. We have separately presented those activities that span across both. Further details on our cost benefits assessments on these and all our planned activities is presented in our RIIO-2 CBA Annex 2[34]. Within these groupings, delivery coordination with external parties is discussed, in terms of both expected costs and benefits, giving an idea of responsibilities outside of the ESO.

Regarding decarbonisation, current calculations within some of the data and digital activities contributing to a reduction in carbon emissions are presented, followed by a narrative on possible factors which may increase our carbon footprint and ways we will look to further asses and decarbonise.

7.1 Cost Benefit

7.1.1 Pillar 1 – Deliver open data and digital market enablement

Taking a whole system energy approach to connections (A14) and improving network access planning (A16) are our primary data and digital activities associated with enabling realisation of this pillar. They will help us embed the principle of 'presumed open', making all our shareable data available in an accessible format to inform efficient business decision-making across the industry and drive innovation, removing barriers to market participation and transforming the customer experience through digital enablement.

For activity A14, our connections proposals will ensure that we continue to support the ongoing increase in numbers and variety of market participants looking to connect to the network, contributing towards our Trusted Partner ambition and facilitating whole system outcomes. For activity A16, these proposals will enable roll out of best practice access planning processes developed in Scotland in RIIO-1 across the whole Great Britain transmission system. We will support increased levels of co-ordination across the transmission-distribution interface to deliver significant consumer benefits.

As set out in the table below, we have calculated that the total net benefits will be £218.31M, against total costs of £14.158M. A14 yields efficiency savings for both the ESO and our customers. These ESO opex savings and customer efficiency savings are added together to make up the total benefits. A16 saves money by forecasting constraint cost reductions due to increased safety and reliability. The constraint costs for England and Wales are multiplied by the forecast reduction % to incur the expected overall benefit.

Activity (£M)	Benefits	Capex	Opex	Total costs	Net Benefits
A14 Taking a whole electricity system approach to connections	8.1	1.8	4.58	6.38	1.72
A16 Delivering consumer benefits from improved network access planning	224.37	4.8	2.98	7.78	216.59
Pillar 1 Total	**232.47**	**6.6**	**7.56**	**14.16**	**218.31**

To undertake successful delivery of activities spanning pillar 1, we expect delivery coordination to be required between the ESO, Distribution Network Operators (DNO's), Transmission Operators (TO's) and relevant connecting parties. In addition, there would be shared responsibilities in terms of cost and performance to realise the potential benefits.

We could expect a cost impact would arise for DNO's, TO's and connecting parties in order to interface with the connection's hub for activity A14. With these costs incurred, a benefit for any connecting party would be reduced barriers to connection which could save a lot of time (and possibly cost) in the process of connecting to the network. For A16, it is expected that lower bills than would otherwise be the case would be delivered for consumers, with TO's and DNO's expecting to incur a cost. This would come from the need to provide new information into ESO systems and processes.

7.1.2 Pillar 2 - Build our core capability through digital technology

Our proposals for Control centre architecture and systems (A1) give us the control centre systems and processes to analyse, optimise, schedule and dispatch the zero-carbon energy market of the future. Our proposals for Control centre training and simulation (A2) help deliver our zero-carbon operation ambition giving us the training and simulation capability to be able to operate the zero-carbon system of the future. Our

[34] RIIO-2 CBA Annex 2 - https://www.nationalgrideso.com/document/158061/download

proposals for restoration (A3) deliver a more streamlined restart process for disaster recovery and are fundamental to delivering our zero-carbon operation ambition and competition in the services we procure.

Our plans to develop code and charging arrangements that are fit for the future (A6.5) are key to achieving our strategic goals for Competition Everywhere as an electricity system that can operate Carbon free and whole energy system solutions. A whole system Grid code will remove barriers to entry and help to align industry arrangements across transmission and distribution. Proposals for Taking a whole system approach to promote zero carbon operability (A15) underpin and enable our zero-carbon system operation ambition through the development of data exchange, offline modelling capability and system operation tools.

As set out in the table below, we have calculated that the total net benefits will be £611.712M, against total costs of £291.085M. Benefits for these activities arise from a range of differing factors.

- A1 delivers benefits from savings due to reduced CO2 emissions resulting in reduced environmental damage. For consumers – carbon savings, greater interconnection, utilising flexible technology, inertia forecasting, improved situational awareness would all deliver lower bills than would otherwise be the case. Lastly – Reduced balancing mechanism outage downtime delivers profit through improved safety and reliability.
- A2 delivers benefits from reduced resource costs and decreased training costs – causing lower bills than would otherwise be the case.
- A3 yields benefits from both carbon savings as reduced cost and environmental damage.
- A6.5 delivers the benefit of reduced barriers to entry for any projects interacting with the new grid code, resulting in lower bills than would otherwise be the case.
- A15 delivers benefits through a whole system Network Operations Assessment (NOA), asset savings and carbon savings. NOA and asset savings deliver lower bills than would otherwise be the case whereas carbon savings deliver a monetary benefit through reduced environmental damage.

Activity (£M)	Benefits	Capex	Opex	Total costs	Net Benefits
A1 Control centre architecture and systems	305.04	120.31	32.83	153.14	151.9
A2 Control centre training and simulation	34.96	5.82	15.91	21.73	13.23
A3 Restoration	5.04	25	8.56	33.56	-28.52
A6.5 Digitalised grid code by 2025	10	1.56	4.50	6.07	3.93
A15 Taking a whole system approach to promote zero carbon operability	548	52.49	24.1	76.59	471.17
Pillar 2 total	**903.04**	**205.18**	**85.91**	**291.09**	**611.71**

To undertake successful delivery of activities spanning pillar 2, coordination for delivery would be required between the TO, DNO's, Academia (Who run training courses), relevant code administrators and commercial solutions providers. In line with our pillar 1 activities we would expect co-ordination with other parties will be required to ensure efficient delivery and to realise the benefits,

The following illustrates potential impacts of our pillar 2 planned activities on our energy system stakeholders:

- A1 - a cost impact would arise for DNO's, TO's, and market participants as there may be changes to their systems required in order to interface with ours (ESO). Benefits would be delivered to society through lower bills and reduced carbon emissions, whereas market participants would benefit from greater transparency and confidence in decision making.
- A2 - would benefit society through lower bills, with no other major costs to external parties observed, whilst A3 would deliver quicker restoration times to society through training exercises with DNO's and other task groups concerned, possibly incurring a share of the cost of this themselves.
- A6.5 incurs a cost for DNO's and TO's to review this code and hold relevant consultations, whilst delivering on reduced barriers to entry, potentially delivering new market participants. A15 would possibly create a cost for market participants to provide new services.

7.1.3 Activities which span both pillars

Our plans for future balancing markets (A4) will see us make significant steps towards our ambition for Competition Everywhere. Where competition already exists, we are focusing on removing barriers to entry by

moving procurement closer to real time and making it much easier to provide services through the Single Markets Platform. In support of our ambition to be able to operate an electricity system carbon free we are also developing competitive approaches for system services such as stability and reactive power.

Our proposals for Transparency and Open data (A17) drive progress towards our Trusted Partner ambition as well as our ambition to be able to operate a zero-carbon system. Through transparency of our actions, stakeholder and market participants will be able to understand, and have greater confidence in, the decisions that we take to balance the system in real-time. In addition, by providing far greater diversity and volumes of operational and market data we anticipate that we will stimulate a fresh wave of innovation in low carbon and whole electricity system operation solutions. These solutions may mature into tools that will help us to operate the zero-carbon system of the future.

As set out in the table below, we have calculated that the total net benefits for cross pillar activities are £53.373M, against total costs of £52.755M. Benefits for both activities arise from a range of differing factors. Building the future balancing service and wholesale markets delivers benefits by using more liquid response and reserve markets as well as buying the optimal levels of response, resulting in lower bills than would otherwise be the case.

The delivery of the open data platform incurs a net cost to the ESO however is a key enabler for other benefits delivered demonstrating control room decision making transparency, market data and energy system analysis. This platform will also enable relevant systems and markets to operate far more efficiently – driving lower bills.

Activity (£M)	Benefits	Capex	Opex	Total costs	Net Benefits
A4 Build the future balancing service and wholesale markets	106.13	10.98	25.77	36.76	69.37
A17 Open data (Digital data platform)	0	16	0	16	-16
Cross-pillar Total	**106.13**	**26.98**	**25.77**	**52.76**	**53.37**

To undertake successful delivery of these activities will require coordination between the ESO and DNO's. We would also expect that a cost impact of these activities on wider parties, such as market participants, where changes to systems and processes would be required to enable effective interfacing with our markets. However, for society, the impact of reduced carbon emissions can also be positively monetised (see below).

7.2 Decarbonisation

In order to model the impact of our planned data and digital activities on the decarbonisation of the ESO, we have used two of the possible future energy scenarios from our Future Energy Scenario 2019 publication[35]. One being Two Degrees (TD), which shows a decentralised scenario and the other one being Steady Progression (SP), which shows a present-day centralised scenario. The table below explains these terms and the key measures associated with our decarbonisation modelling.

Unit	Term	Definition / Application
gCO2/kWh	Carbon intensity	Number of grams of CO2 produced / reduced per kilowatt hour (kWh) of power
SP	Steady Progression	Future energy scenario, which represents a slow uptake of low carbon technology
TD	Two Degrees	Future energy scenario, which represents a faster uptake of low carbon technology and decentralisation
TWh	Expected demand	Total expected demand for electricity across the UK energy system under a proposed future scenario in Terawatt hours (TWh)
£/tCO2e	Carbon price	The price of carbon per tonne of CO2 equivalent. The prices used in our calculations have been published by the Department of Business, Energy and Industrial Strategy (BEIS).[36]
GWh	Carbon generation reduction	Total expected reduction in electricity demand across the UK energy system as a proxy for carbon generation reduction. Gigawatt hours (GWh)
RDPs	Regional development programmes completed (per year)	RDPs highlight new ways of working with a range of network companies to realise operational efficiencies.

We have started to assess the potential impact of our planned digitalisation related activities in respect to decarbonisation. We will undertake further work to quantify the full impact of our digitalisation strategy on achieving our 2025 net zero ambition and establish appropriate mitigation plans. We expect that digitalisation, with the associated increase in volumes and flows of data, will increase carbon emissions. This includes through the running of data centres and implementation of digital technologies, such as digital twins. We would however also expect that as technologies advance there would be some efficiencies realised that would mitigate increasing carbon emissions.

We have set out below our initial assessments and quantified potential carbon impacts on the following activities:

- Control centre architecture and systems (A1)
- Restoration (A3)
- Taking a whole electricity approach to promote zero carbon operability (A15)

To calculate the adjusted savings for A1 (method shown in the “calculation” section), carbon intensity was compared for each scenario before subtracting the difference to obtain a reduction in carbon intensity. This reduction in carbon intensity was then multiplied by the expected demand and carbon price to obtain the expected saving. To convert this to the overall adjusted benefit, attributable savings and percentage of maximum benefits claimed were considered.

To calculate the benefit for reduced emissions in activity A3, the estimated reduction on carbon emissions (in tonnes) was multiplied by the carbon price to give a value for savings. The total benefit for activity A15 – The CO2 saved (in tonnes) was multiplied by the carbon price and the number of regional development programmes completed.

Carbon savings have been identified as cash benefits, that have already been monetised as outlined in the cost-benefit section above. A1 would drive a monetary benefit through a reduction in carbon intensity as a presumed change in future energy scenario from Steady Progression to Two Degrees. We calculate that this activity would realise nearly a third reduction in carbon intensity to 72.2 gCO2/kWh.

Compared with a counterfactual scenario of continuing to run the current system, calculated carbon savings from the three activities (A1, A3 and A15) make considerable positive steps towards net-zero, with remaining

[35] National Grid ESO – FES 2019 https://www.nationalgrideso.com/sites/eso/files/documents/fes-2019.pdf

[36] Department of Business, Energy and Industrial Strategy https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/794188/2018-short-term-traded-carbon-values-for-modelling-purposes.pdf

carbon intensity becoming easier to offset than today's values. Our calculations for these three activities are set out in the tables below, with figures rounded to 2 decimal places.

Adjusted savings for Control centre architecture and systems (A1)

	2021/22	2022/23	2023/24	2024/25	2025/26	Calculation
Carbon intensity SP gCO2/kWh	136.44	119.55	128.48	123.71	110.89	A
Carbon intensity TD gCO2/kWh	69.19	57.56	53.57	44.33	38.691	B
Reduction gCO2/kWh	67.25	61.99	74.91	79.38	72.21	C = A - B
Expected demand TWh (Two Degrees)	305.43	304.23	303.50	304.10	303.87	D
Carbon price £/tCO2e (calendar year adjusted to FY)	14.70	15.25	15.83	16.63	19.24	E
Saving (£M)	301.84	287.62	359.84	401,44	422.17	F = C x D x E (adjusted for units)
Attributable saving (£M)	15.10	14.38	17.99	20.10	21.11	G = 5% x F
Percentage of maximum annual benefit claimed	5%	25%	60%	80%	94%	H
Adjusted (£M)	**0.75**	**3.60**	**10.80**	**16.10**	**19.84**	I = G x H

Benefits for reduction in CO2 (Tonnes) for Restoration (A3)

	2021/22	2022/23	2023/24	2024/25	2025/26	Calculation
Reduction in CO2 (tonnes)	0	0	0	0	32,400	A
Carbon price £/tCO2e (calendar year adjusted to FY)	14.70	15.25	15.83	16.63	19.24	B
Benefit (£M)	**0**	**0**	**0**	**0**	**0.62**	C = A x B

Benefits for taking a whole electricity approach to promote zero carbon operability (A15)

	2021/22	2022/23	2023/24	2024/25	2025/26	Calculation
Carbon intensity Steady Progression (gCO2/kWh)	136.44	119.55	128.48	123.71	110.89	A
Carbon generation reduction (GWh)	974	974	974	974	974	B = 278/1000*0.4* 365*24
CO2 saved (Tonnes)	132,906	116,457	125,156	120,504	108,022	C = A x B (units cancel)
Carbon price (£/tonneCO2e)	14.70	15.25	15.83	16.63	19.24	D
RDPs completed	0	0	1	1	1	E
Benefit (£M)	**0**	**0**	**1.98**	**2.00**	**2.10**	F = C x D x E

Appendices

Appendix A – User Journeys

Single Markets Platform

By end of RIIO-1, I will manage …

- Relevant Market Data from various sources

By end of RIIO-1, I will operate with …

- Different systems to manage small Ancillary Service providers
- Different systems and processes to provide Ancillary Services
- End to end processes reliant on emails and spreadsheets flows

IT Investment in …

- Integration via site and Intranet user experience
- Integration via API direct consumption and creation of new APIs
- Analytics capabilities
- Workflow capabilities
- Sandbox capabilities
- Applets

will enable me in RIIO-2 to manage …

- All relevant market data in a single place
- A single platform designed for any type and size of Ancillary Service providers
- Efficient end to end processes enabled via online workflows and communications

will enable me in RIIO-2 to operate with …

- A simpler and faster way to test new markets and their effectiveness
- A place where other party is covering my obligations
- One interface where I can go through any aspect of providing Ancillary Services

Digitalised Grid Code

Code Management User Journey

By the end of RIIO-1, the code administration process is :

Manual
Designed for tens of participants
Perceived to be too slow by stakeholders
Difficult to navigate

The codes:

Consist of thousands of pages of text & supporting documents
Are separate for T&D (Grid Code)

IT Investment in …

- AI enabled guided navigation and search capability
- web based document workflow

Will enable me in RIIO-2, as an external participant, to:

- Have easy access to information that I can trust
- View a harmonised Transmission & Distribution Grid Code
- See all the elements that are relevant to me
- See which areas are subject to change, and receive targeted alerts.
- Access FAQs that are relevant to me.
- Be directed to the relevant sections when I register an asset (could have)

Will enable me in RIIO-2, as an internal user, to:

- Operate the process with hundreds of participants
- Make the digital version the legal document
- Automatically publish changes when they are approved (and undo)
- Find out which areas participants are interested in.
- Have a secure system
- Have full version control, access control, and signoff capability

Planning and outage data exchange

Planning & Outage Data Exchange

By the end of RIIO-1, I manage outages…

- With a new outage notification and planning tool to provide better service to customers.
- With manual data validation
- With systems designed to interact with a limited number of external stakeholders
- With DNO network data that is submitted to the ESO once a year.

IT Investment in …

- More frequent exchange of network data with DNOs and TOs.
- DNO access to the outage planning tools.
- Outage Visualisation
- Tools to optimise system access in the long and short term.
- Machine learning for outage planning.
- CIM compliant outage data.
- Cloud based database which can interact with different tools
- Automated data validation

will enable my outage management in RIIO-2 to …

Support 2 way data exchange of network & generation information with DNOs	Take better account of planned DNO network changes.	Have greater visibility of DNO outages that impact the transmission network (and vice versa)	Provide whole system stakeholder notifications of outages
Allow distributed parties to provide services to facilitate outages.	Give customers visibility of outages affecting them	Support short notice outage requests	Handle significantly increased types, volumes & frequency of data

Balancing and control

By end of RIIO-1, I will manage …

- BMUs connected at transmission level
- The network at transmission level only
- 4 number of ICs representing 4 GWs
- Specific critical interrelated subsets of data
- More volatile frequency deviations

By end of RIIO-1, I will operate with …

- Operational data transmitted via secure dedicated EDL/EDT links
- Small to medium energy volumes from batteries
- Decreasing levels of Inertia
- Years of experience with legacy systems and energy products (response, reserve, voltage) and processes (BOA creation, procurement of needs via tenders)
- Evolving Control Room roles and responsibilities
- Cardinal Points
- Environment where control engineer is the center of all decision making

IT Investment in …

- Transforming our real-time situational awareness tools (alarm management, modelling, and training simulation tools)
- Enhancing online and offline network simulation and modelling tools
- Enhancing decision support tools (e.g. machine learning)
- Tools to enable bulk dispatch for all types of services
- New tools, processes and functionalities to manage outcomes and interactions of new auctions and markets
- Tools to manage Inertia as a service
- Modernising Control Room environment and supporting infrastructure

will enable me in RIIO-2 to manage …

A wider range of generation types and sizes (of 1MW and upwards) at individual and group level	BMUs referenced to various GSP points within a GSP group area (DNO area)	Exponential amounts of data with complex interactions	
And coordinate with DNO/DSO networks and 15number of ICs representing 17.9 GWs	BMUs connected at transmission and distribution level	Frequency deviations harder to predict	
All Control Room activities with less manual intervention	Whole System demand forecast	A more complex system at lower cost	And dispatch economically agnostic of unit volume, technology, fuel source or location

will enable me in RIIO-2 to operate with …

Operational data transmitted via secure but less expensive technologies	Increasing penetration from batteries and other technologies	New suite of AS and European Market products and processes	
Wind and solar forecasts modelled as connected generation	Further lower levels of Inertia	Work to as many analysis points as required	
Real time study tools that feed dispatch decisions	Dispatch units automatically	Greater resilience to poor data	Clear and transparent actions based on economic and technical constraints

Network modelling

Network Modelling

By the end of RIIO-1 I do my analysis …

- Based on discrete and historical events
- For few specific scenarios
- Mostly considering transmission investment
- Not considering increasing system complexity
- Primarily for internal purposes
- Using different tools and datasets for different purposes

IT Investment in …

- New and more complex modelling tools (for example, short circuit levels, virtual powerplants)
- Comparison tools for multi-scenario analysis
- Integration of economic analysis & network modelling.
- Regular asset health investment to handle greater data volumes and the increased performance needs of more complex modelling.
- Regular modelling tool upgrades to leverage international and GB best practice.
- User-developed models & algorithms
- Agile and iterative enhancements.
- Automation & simplification for efficiency & enablement. Machine learning for network modelling. Robotic process automation

will enable my analysis in RIIO-2 to …

Deal with more complex models arising from new operability issues	**Be run quickly for multiple scenarios**	**Understand the operating envelope at more time points**	**Use an interchangeable suite of tools on a common dataset, exchange data seamlessly between tools**	**Consider market & transmission investments**
Adjust granularity of analysis dependent on need & timeframe	**Model deeper into the DNO networks**	**Carry out probabilistic modelling**	**Support increased regional coordination (CACM/ENTSO-E/CORESO)**	**Enable external stakeholder access**

Training and simulation systems

By end of RIIO-1, I will have …

- Adhoc training
- 6 to 9 months time period to get authorised into a new role

IT Investment in …

- A training simulator based on advanced System Modelling & Simulation
- Integrating simulating capabilities in other systems

will enable me in the RIIO-2 to …

Train DSOs and other industry stakeholders whilst also learning from them	**Test new operational policies to react to new market changes**	**Have consistent operational quality**	**Have lower cost and quicker training**	**Create complex authorisation and scenario based training with ease**	**Facilitate lessons learnt learning based on rerun of specific operational days and overlay of best standard operational behaviour**

Appendix B – Delivering on Energy Data Taskforce Recommendations

EDTF Recommendation	ESO support actions
1 - Digitalisation of the energy system (Principle) - the energy sector should adopt the principle of "Digitalisation of the Energy System" in the consumers' interest in line with supporting principles of New data needs, Continuous improvement and Digitalisation strategies.	• **A Stakeholder driven digitalisation strategy** We will continue to engage a wide range of consumer and wider stakeholders to align and shape our Digitalisation Strategies and planned activities to their changing user needs. We will engage them through a variety of channels, such as our Technical Advisory Council, electricity operational and energy industry groups and Ofgem's/BEIS data and digital service provider forums. • **Pillar 2 - Building our core capability through digital technology** We will identify, capture and use the right data to transform the way we operate, employing use cases to inform deploying data and advanced digital technologies, such as AI and machine learning to supercharge our capability and deliver enhanced outcomes for current and future consumers. We will replace our internal data management systems with a new Data and Analytics Platform (that pulls together data from a variety of critical national infrastructure (CNI) and non-CNI sources) and a Digital Engagement Platform. • **Pillar 3 - Transform our organisational culture and digital ways of working** We will address the challenges of future talent acquisition and retention in a world where highly skilled data users will be in high demand. We will develop our people's data and digital skills and apply a mixed sourcing strategy to ensure we have the resources we need, when we need them and can flex our resource base.
2. Maximising the value of data (Principle) - the energy sector should adopt the principle of 'presumed open' supported by requirements that data is discoverable, searchable and understandable with common structures, interfaces and standards.	• **Pillar 1 – Deliver open data and digital market enablement** We will make our data discoverable, searchable and understandable. We will develop a data portal where all our shareable data is accessible in one place in a user-friendly format. We will also support data users in understanding the data through explanation and analysis where required. We will make our data open to drive industry collaboration and remove barriers to entry for new market participants, some of whom may be unfamiliar with the energy industry. • **Embedding data and digital best practice** We have and will continue to apply the principle of presumed open and will share all the data deemed sharable according to an "Openness Triage" process.
3. Visibility of data (Building block) - a Data Catalogue should be established to provide visibility through standardised metadata of the energy system datasets across Government, the regulator and industry.	• **Principle 1 - Deliver open data and digital market enablement** We will continue to enable open data through the development of a data portal and support the development of industry-wide data management tools, such as the Data Catalogue. Ensuring data is discoverable, searchable and understandable. We will enable ESO and operators of the distribution system better visibility of what services are being provided to whom, as well as any network limitations on service provision, via our single markets platform. • **Embedding data and digital best practice** We will actively support the development of an industry data catalogue through publishing a catalogue of the data that we share with metadata.
4. Coordination of asset registration (Building block) An Asset Registration Strategy should be established to coordinate	• **Pillar 1 – Delivering open data and digital market enablement** We will fully support the coordination of asset registration across markets and network boundaries to reduce the administrative burden for parties that wish to participate in ESO markets, such as balancing services markets or the Capacity Market.

registration of energy assets, simplifying the experience for consumers through a user-friendly interface to increase registration compliance, improve the reliability of data and improve the efficiency of data collection.	We will implement a consolidated asset register for generators and other assets participating in the Balancing Mechanism and Ancillary Services to underpin presumed Open Data sharing and net zero carbon operations. We will collaborate with UK Power Networks, SP Energy Networks and Electron to develop and demonstrate an asset register for energy resources.
5. Visibility of infrastructure and assets (Building block) A unified Digital System Map of the energy system should be established to increase visibility of the infrastructure and assets, enable optimisation of investment and inform the creation of new markets.	• **Pillar 2 – Build our core capability through digital technology** We hold, and are developing, data sets that can enrich a unified digital system map of the energy system. These include our development of the connections heat maps, showing where capacity can be found on the network, and information on operability issues on different parts of the network may lend themselves well to this. We will provide an online portal for stakeholders to see a visual representation of network needs and to potentially test high-level solutions.