nationalgridESO

ESO RIIO-2 Business Plan
Annex 4 – Technology investment report

9 December 2019

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1. Introduction

This annex includes supplementary information on the IT investments directly relating to the ESO and the shared investments made by National Grid group IT that support the ESO and the wider National Grid group.

Technology investments are split into two categories – IT investments specifically for the ESO (as set out in the theme chapters), and shared IT investments made centrally within National Grid group IT to benefit the ESO and the wider group.

These shared investments use National Grid group IT to deliver the IT environment that provides ESO with efficient, scalable, reliable IT services. This enables the economies of scale for procurement and unlocks access to global support providers.

The following annex highlights our key assumptions for both categories of investment.

1.1. IT investments specific to the ESO ambition

In this two-year business plan, our view of IT investment specific to the ESO (as set out in the theme chapters) amounts to £157 million (£122 million capex, £34 million opex). The full five-year roadmap totals £407 million (£327 million capex, £80 million opex).

This information details each investment line from an IT perspective. Some investment lines cut across every theme. The market and customer benefits from these investments are covered in each theme chapter. This annex focuses on the milestones within each investment line that support them.

Each investment consists of a capex and an opex element. Where an investment is expected to be met either partially or fully by a cloud solution, this is treated as opex. However, this may change as we develop our solution design.

Each investment line is categorised to show where possible: the current context and system capability; the need for change and the internal or external use case for it; high-level delivery roadmap; and where we will invest resources. There are some investment lines that, given their ongoing operational nature, do not allow us to include this detail. These are:

- Balancing asset health - along with building the enhanced balancing capabilities we need to ensure we continue providing at least the same level of service as now. We will need to carry on with lifecycle upgrades, enhancement for near term requirements and transition to new capabilities.
- Electricity National Control Centre (ENCC) asset health - to handle unforeseen events and emergency situations we will still need to invest in maintaining our stand-alone specific situational awareness tools and last resort resilient bespoke communication links.
- Ancillary service dispatch - integration of the Ancillary Services Dispatch Platform (ASDP) capabilities developed in RIIO-1 into the core balancing capabilities and processes and expanding it to cover any new ancillary services. This will also be integrated with the single market platform so new ancillary services can be consistently managed and dispatched.
- Forecasting enhancements – continuing with the investment made under RIIO-1, to enhance our mathematical forecasting models and refresh the forecasting system in line with our policies.
- Electricity Market Reform (EMR) and Contracts for Difference (CfD) improvements – this investment will allow us to continuously improve user experience based on external feedback or our own expertise.

We expect most of the investments to follow an iterative approach, as explained in our strategy - although they appear in this document to have a single go live date (as per a waterfall delivery methodology). This means they will experience various implementation cycles and may comprise of different modules.

Both the nature and impact of regulatory change are very difficult to predict. Unexpected changes could occur during the price control period, which may lead us to use Ofgem's proposed cost trigger mechanism. Mapping of RIIO-2 activities to technology investment lines is shown in Appendix F.

While values are shown to one decimal place, the underlying calculations are made to 15 significant figures. As these numbers are rounded for display, there may be some visual inconsistency within the tables.

1.2. Shared investments supporting the ESO

Sections 7-11 detail the investment approach to the shared investments.

As a group, we will invest £362 million capex over five years (£192 million in the first two years) of which £98 million is allocated to ESO (£54 million in the first two years).

	2021/22	2022/23	2023/24	2024/25	2025/26	Group Total	ESO Total
Business services	15.9	18.3	12.3	11.3	17.7	75.5	12.2
End user computing	5.5	4.5	5.0	4.5	4.5	24.0	4.4
Hosting	45.2	22.2	15.0	16.5	7.5	106.3	33.3
IT operations and tooling	13.0	4.0	2.0	2.0	2.0	23.0	3.9
Enterprise data network	9.5	11.9	12.0	6.7	6.3	46.5	12.0
Cyber	25.5	16.3	13.3	15.4	16.0	86.5	32.7
Total	**114.5**	**77.2**	**59.7**	**56.4**	**54.0**	**361.8**	**98.4**

Figure 1 – Shared capex investment, 18/19 pricing, £ million, opex not shown.

2. Theme 1 investment lines

The electricity market is expected to undergo transformational change in the next five to ten years. Large transmission-connected generation is predicted to decline, and there will be significant growth in small distribution connected generators. We will need significant expansion in our balancing and control capabilities to deal with a large increase in participants and this will drive a need for more automation. The ability to optimise resources across the transmission and distribution networks will also be required, as well as establishing new and closer to real time local, Great Britain and European markets.

2.1. 110 Network control

Current stage:

Scoping	Start-up	Requirements and design	Development and testing	Implementation

2.1.1 Overview

This investment will introduce new real-time situational awareness capability giving control centre operators a better understanding of changing network limitations, leading to a more efficient risk-based operation of the system. This capability will need new alarm management, modelling and visualisation tools. We will also deliver training simulation tools combined with artificial intelligence and digital twin technology relevant to this investment.

2.1.2 Current state

Our integrated electricity management system (IEMS) provides our core network transmission control capabilities. This allows real-time operation and monitoring of the transmission system and is categorised as critical national infrastructure (CNI). It is a shared system with National Grid Electricity Transmission (NGET) as it enables the safe remote operation of substation equipment, and real-time monitoring of the network, receiving data from the other GB transmission owners (TOs) to give a full picture of the GB network.

As part of NGET / ESO legal separation, the dedicated IEMS hardware and software were updated in RIIO-1 and its data were also isolated so that both NGET and ESO can only see the data relevant to their role, as per regulation. An asset health upgrade/refresh will be required in RIIO-2, currently planned for 2023.

2.1.3 Case for change

As part of our RIIO-2 business plan submission, and given our legal separation obligations, we decided to review our network control capabilities in combination with NGET.

On the back of that review and considering our RIIO-2 ambitions we came to the realisation that ESO requires capabilities to address its situational awareness needs. After assessing the capabilities of current supervisory control and data acquisition (SCADA) solution, we concluded that it does not address our needs or supports our business and stakeholder ambitions, such as data analysis and provision. This means ESO requires a new tool to meet its license conditions that may interface with the IEMS tool which NGET has signalled it requires to run their business.

The ESO no longer receives directly some network data and signals, and as such will need different tools to continue to perform its role efficiently. These will deliver much more visualisation capabilities alongside a subset of network alarms, as per ESO needs.

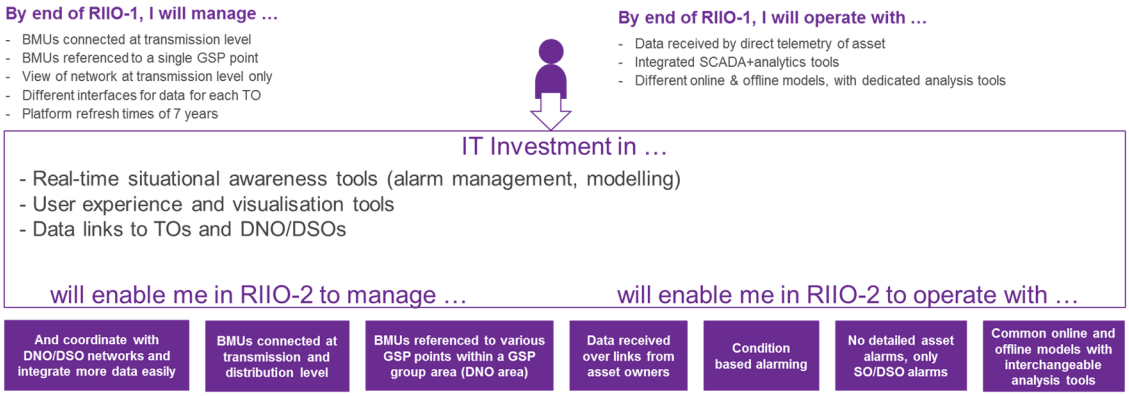

Figure 2 – Use case, investment and outcome expectation

2.1.4 Roadmap

During the remainder of RIIO-1, we will be working with NGET to validate:

- what current capabilities can or should be shared
- what new capabilities ESO requires
- extended support of current system after 2023
- total cost of ownership
- high-level ESO and NGET programme plans.

The outcomes will inform our strategic project as we start RIIO-2.

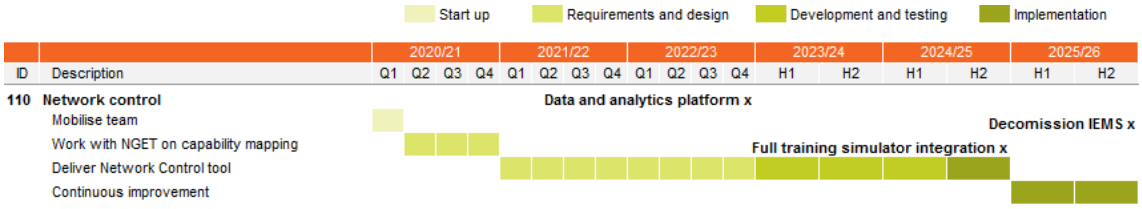

Figure 3 – Delivery plan

2.1.5 Future state

The new capabilities will integrate with IT investment 220 Data and analytics platform, ensuring a single network model for control centre operators.

Although not switching or moving transformers, i.e. no large-scale asset control, the new tool will still need to send signals to ask for services (e.g. sending instructions to the DSOs' automated network management (ANM) systems). In a similar way, we will still need to see substation configurations even if we have no need to receive all the detailed alarms.

2.1.6 Approach

We will develop new situational awareness applications for operators. These will capture, store, analyse, and present data from multiple new sources and forms in real time.

These applications are supported by IT investment 220 Data and analytics platform and they will be developed to meet the RIIO-2 ambition.

A wide range of application and data integration styles, which will be used to exchange situational data with DSOs, TOs, and other industry participants. These data transactions provide a model of the network in real time and allow combinations of balancing actions to be assessed against the current network state.

Artificial intelligence methods will identify actual and likely operational incidents from the new operational datasets in RIIO-2. We will use other artificial intelligence methods to identify the correct remedial or protective actions.

In the medium term these integration capabilities will be used to support the current IEMS system.

We expect to complete much of the development and integration work and scale through our partners as required.

The primarily cloud-based nature of IT investment 220 Data and analytics platform will align with the rest of the industry to allow the exchange of data via cloud storage.

2.1.7 Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	2.9	5.2	6.5	7.9	4.5	**27.0**
Opex	0.3	0.6	0.7	0.9	0.5	**3.0**
Total	**3.3**	**5.8**	**7.3**	**8.8**	**5.0**	**30.0**
Cumulative RTB* increase	0.0	0.1	0.2	0.4	0.6	**1.3**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	20.0
High	35.0

Figure 4 - investment costs

Our costs for this investment present themselves within Gartner's range. The reason for these being closer to the higher estimate is related to the need to expand our situational awareness capabilities beyond the average type of tools developed historically (which form the basis for Gartner's benchmark). This need is justified given we are an island system with increasing levels of complexity and coordination.

2.1.8 Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
Extension of legacy tool not possible, leading to unexpected levels of work or does not enable new tool implementation date.	• Engage early on with tool suppliers and support teams to agree life extension plans. • Reprioritise plan to decrease impacts. • Engage with NGET to understand other available options.	3	3
NGET tool delivery gets delayed, meaning the ESO will need to continue supporting the legacy tool for longer than intended.	• Have close planning coordination with NGET through full project lifecycle. • Agree to prioritise delivery of functionality that enables replacement of legacy tool as minimum viable product.	2	1

2.1.9 Options

Option(s)	Pros	Cons
Not invest in this area		• Leaves operational critical tools without support and underperforming. • Increases inefficiencies in our processes and operational actions. • Increases spend on other RIIO-2 investment lines. • Leaves NGET with no support to invest in their tools. • Increases cyber security risk. • Puts at risk 2025 ambition to be able to operate a carbon free electricity system. • Puts complying with regulatory changes at risk.
Invest in legacy tools		• Does not enable economic data sharing. • Requires refresh of current tools. • Increases RTB risk. • Adds risk of not being able to retain or attract legacy skill resourcing/SME. • Does not support investment scalability and flexibility.

Option(s)	Pros	Cons
		• Restricts alignment to industry changes. • Increases delivery risk of making changes on time and efficiently.
Deliver the new capabilities by 2023 aligned with NGET	• Faster delivery of this investment's benefits. • Simpler data transfer between tools.	• High delivery risk given previous similar projects have taken around five years to deliver. • Puts other prioritised consumer value areas at risk in first years of RIIO-2 plan.
Deliver the new capabilities by 2025 with NGET delivering in 2023	• Faster delivery of NGET benefits.	• Double expenditure as a full refresh of the legacy tool will still be required plus supporting data transition between systems. • Adds RTB increase until 2025.
Deliver the new capabilities by 2025 aligned with NGET	• Meets needs of both ESO and NGET ambitions. • Simpler data transfer between tools. • Aligns milestones in delivery projects. • Keeps prioritised costumer value areas on their current plan.	• Full benefits from this investment line are achieved towards end of RIIO-2 period.

2.2. 130 Emergent technology and system management

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

2.2.1 Overview

This investment will ensure control centre users have the tools to manage operational issues highlighted in the Operability Strategy Report, allowing them to monitor the system in real time and make decisions to counter any critical changes.

2.2.2 Current state

Our Operability Strategy Report is updated every six months to include key challenges that affect our real-time operations. To address these challenges, it usually requires development of specific and bespoke operational tools.

Depending on their urgency, impact and complexity, solutions can range from user-developed tools to real-time data feed tools integrated with our IT estate.

System conditions can quickly change, often surfacing challenges that need to be tackled at short notice. One example is inertia, now a key operational constraint leading to significant increase in balancing costs if not managed properly. During RIIO-1, we had to invest in real-time system data for its monitoring and forecasting.

2.2.3 Case for change

During RIIO-2, we expect other system parameters and conditions to evolve at a faster pace.

This is a programme of work to address operational challenges and constraints, e.g. response levels, largest loss.

Although quickly developed and adding real value, user developed tools require careful management and can only be used for limited operational scenarios. Relevant user tools will need to be expanded and integrated with either our enhanced balancing capabilities or network control tool.

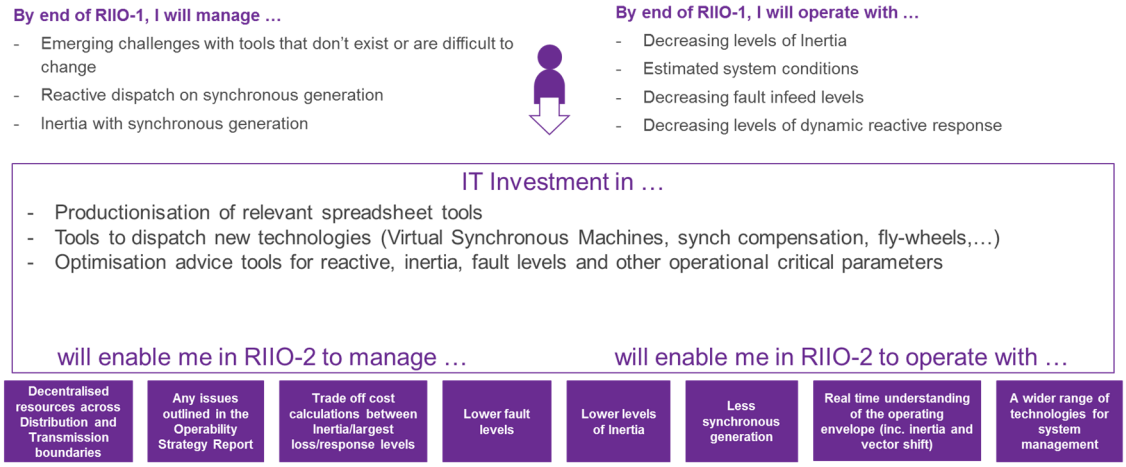

Figure 5 – Use case, investment and outcome expectation

2.2.4 Roadmap

Building on work done in RIIO-1, this investment will enable management of inertia plus management of emergent technologies (such as storage and electric vehicles) or any other challenges affecting our dispatch decisions. All this work will be driven by our biannual Operability Strategy Report and any new tools will be integrated with either our enhanced balancing capabilities or our network control tool.

Throughout RIIO-2 we will prioritise work based on the newest Operability Strategy Report, implementing tools that address industry and operational priorities.

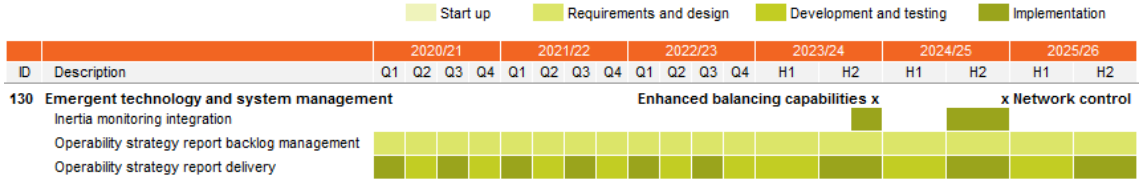

Figure 6 – Delivery plan

2.2.5 Future state

This investment will allow us to tackle new operational challenges more quickly and efficiently throughout RIIO-2. It will use our foundation work, such as the IT investment 220 Data and analytics platform, being built on a modular basis like IT investment 180 Enhanced balancing capability to allow its integration with any other required tool.

It will enable control centre users to manage changes to the system in real time, securely and economically.

2.2.6 Approach

We will develop new components to incorporate new types of network resource and other emergent technologies.

Existing application components will be enhanced to automate this process.

The capabilities added by IT investments 220 Data and analytics platform and 250 Digital engagement platform allow us to include emergent technologies in the evolving ESO IT estate. We will instantly capture information ranging from commercial data to telemetry data to feed into our analytical processes. Operational instructions will be calculated and forwarded to emergent technology control systems for execution.

2.2.7 Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	0.0	1.5	1.7	1.9	1.9	**6.9**
Opex	0.0	0.2	0.2	0.2	0.2	**0.8**
Total	**0.0**	**1.7**	**1.9**	**2.1**	**2.1**	**7.7**
Cumulative RTB* increase	0.0	0.0	0.2	0.4	0.6	**1.2**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	5.0
High	8.0

Figure 7 - investment costs

Although close to Gartner's high range, cost projections for this investment line are mostly derived from the running costs of inertia project and by the bespoke nature of ESO operational tools required to deal with new industry patterns and technologies.

2.2.8 Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
We develop inappropriate tools due to difficulty in predicting how modelling tools will need to evolve in future given changing needs and increased understanding of issues.	• Ensure regular review of requirements throughout RIIO-2 period. • Deploy proof of concept tools as early as possible to gain understanding of modelling needs. • Employ agile delivery principles and flexible, modular applications. • Enable operability team to effectively prioritise investments based on likelihood and impact of system problems.	3	1

2.2.9 Options

Option(s)	Pros	Cons
Not invest in this area		• Does not facilitate new generation technologies or business models to enter the energy markets. • Creates operational risk, staff overheads and technical debt by addressing new operational problems with inefficient processes and workarounds. • Puts at risk 2025 ambition to be able to operate a carbon free electricity system.
Continue with user written tools that are not integrated		• Creates operational risk, staff overheads and technical debt by addressing new operational problems through inefficient solutions and processes. • Increases cyber security risk. • Increases sustainability risk as it depends on SMEs who wrote tools.
Update tools and integrate with data platform, network control and enhanced balancing capability	• Increases transparency of operational actions. • Enables easy and efficient data sharing with our customers.	

Option(s)	Pros	Cons
	• Enables process efficiencies. • Enables better operational decision-making via enhanced data insights. • Supports 2025 ambition to be able to operate a carbon free electricity system. • Allows application support and ensures their scalability.	

2.3. 140 ENCC operator console

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

2.3.1 Overview

This item is for provision of the entire control room user interface and experience. It includes visualisation tools from control centre dashboards to the video wall plus infrastructure costs to update the silver command room.

2.3.2 Current state

Control centre users access many data sources and different applications to do their job. They use multiple individual displays and a video wall that shows a limited set of relevant operational data.

As the control centre operational team is split over two sites some data is shared over phone or email, as is also the case with our silver command room (used to manage emergency situations).

2.3.3 Case for change

Evolving control centre roles and an increase in data sharing for a more complex network, will require investment in user experience. This will take the shape of a single customisable graphical user interface (GUI), with the ability to interact across all relevant applications and present data from different networks.

Effective teamwork and collaboration needs better interactivity and sharing capability, including the flexibility to easily send data from individual screens to the video wall. This means replacing the current video wall with more flexible, cheaper technology. As the ESO, we are the network company covering the whole of Great Britain and need a video wall that allows us to visualise and manage the entire network to the appropriate detail level.

The infrastructure supporting the control centre will also change to allow more efficient interaction with DSOs and other external stakeholders. Better management of emergency situations will mean updating visualisation and communication capabilities in silver command.

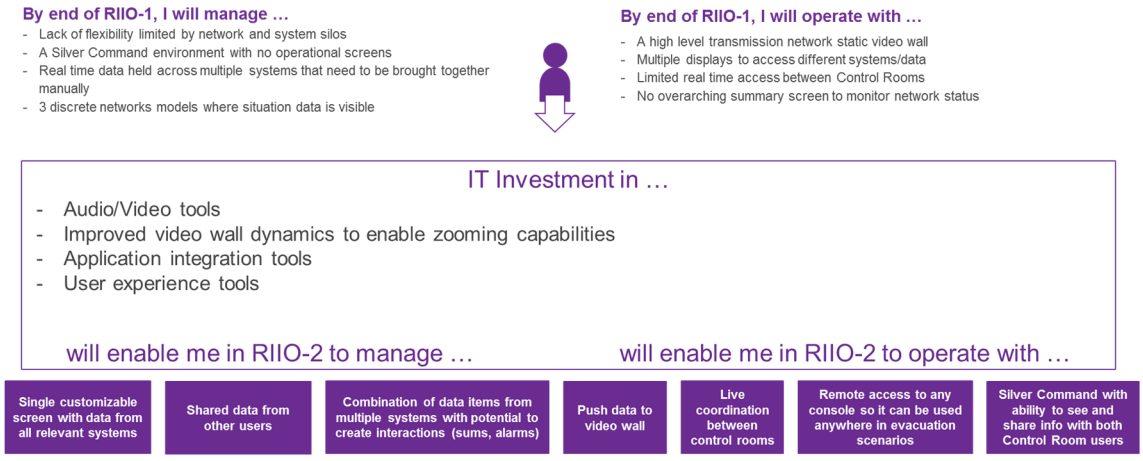

Figure 8 - Use case, investment and outcome expectation

2.3.4 Roadmap

Work is already under way in RIIO-1 to define the activities and structure of the future control centre. RIIO-2 work will align to this and continue to modernise the control centre environment and supporting infrastructure.

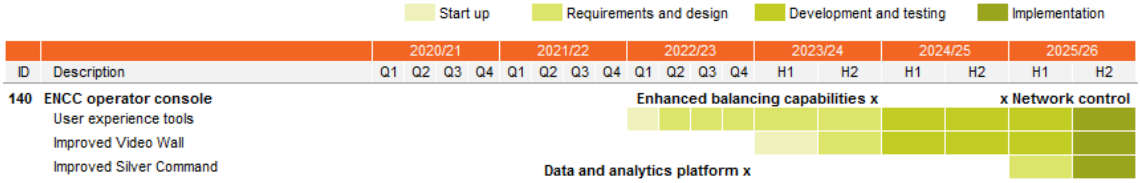

Figure 9 - Delivery Plan

2.3.5 Future state

It will be possible to call up data from the various applications and create a combined set of data for analysis, as shown below, to share with other team members or the whole control centre.

Figure 10 – Future state of control room functionality

This will also give an overall view of the state of the power system in one place enabling control centre managers to make better and quicker informed decisions. In emergency cases, the silver command team will also be able to have faster reaction times and give the most up to date and relevant information to external stakeholders.

Control centre users will get all data from our IT investment 220 Data and analytics platform. Critical modules and applications will be delivered by IT investments 180 Enhanced balancing capability and 110 Network control.

2.3.6 Approach

New application components (e.g. optimisers, network control tools, situational awareness tools and dispatch tools) will be developed with responsive web user interfaces (UIs) that can combine to form large custom UIs, as shown above in Figure 10 – Future state of control room functionality. The web UIs will be written as single page applications (SPAs) using the features of HTML5 to give a highly responsive user experience that reacts instantly to external events.

If required, flexible web UIs will be added to current application components.

The video wall solution from the end of RIIO-1 will be extended to provide the switching and display mirroring function, using a range of control centre technologies at video signal, operating system, or application levels either individually or in combination.

2.3.7 Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	0.0	0.7	0.5	1.7	2.0	**5.0**
Opex	0.0	0.1	0.1	0.2	0.2	**0.6**
Total	**0.0**	**0.8**	**0.6**	**1.9**	**2.2**	**5.5**
Cumulative RTB* increase	0.0	0.0	0.0	0.0	0.1	**0.1**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	2.0
High	5.5

Figure 11 - investment costs

Gartner has based its higher range on our estimation, given the extra functionality requirements in this investment line. Its lower value is associated with control centre spend in other organisations without these extra requirements.

2.3.8 Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
ESO evacuation policies may increase scope/cost as we could be required to invest in a new control centre site.	• Investigate dependencies in start-up phase of project. • Ensure IT tools are configurable and adaptable.	2	2
We may find compatibility issues between the various tools.	• Investigate dependencies in start-up phase of project. • Ensure IT tools are configurable and adaptable.	2	1
Market changes, changes in system conditions are faster than expected leading to further changes.	• Ensure IT tools are configurable and adaptable.	2	1

2.3.9 Options

Option(s)	Pros	Cons
Not invest in this area.		• Creates operational risk, staff overheads and technical debt as it addresses visualisation problems

Option(s)	Pros	Cons
		with inefficient processes and workarounds. • Introduces performance degradation. • Maintains low user experience. • Increases cyber security risk.
Invest in legacy tools.		• Creates operational risk, staff overheads and technical debt as it addresses visualisation problems with inefficient solutions and processes. • Maintains low user experience. • Increases operational security risk. • Increases cyber security risk.
Update tools and integrate with data platform and enhanced balancing capabilities.	• Enables high and consistent user experience. • Enables introduction of efficient processes. • Introduces added value analysis to support operational decision-making.	

2.4. 150 Operational awareness and decision support

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

2.4.1 Overview

This investment will enhance our network modelling capabilities by giving online analysis of voltage and power flow profiles closer to real-time. This will ensure the network is run securely and data exchanges with TOs and DNO / DSOs are timely and correctly assessed.

2.4.2 Current state

Our online and offline network analysis tools were designed to assess the transmission system at a time when its complexity and conditions were stable. They can only study network conditions for specific time periods, a few times a day or for day-ahead purposes and based on offline models. They were developed as standalone tools, as the need for data sharing was not a priority.

2.4.3 Case for change

With the increasing complexity of the transmission network and the need to consider at least part of DNO / DSO networks, we need new tools as well as upgrading existing ones to enable effective decision-making (e.g. machine learning). This investment is also required to support whole system simulation and modelling, both online or offline.

As the generation mix moves towards more variable sources (e.g. wind and solar), the current business processes (based on estimates from historical data) will become unreliable and introduce higher system security risk.

Greater volatility closer to gate closure means we need to run at least high-level network assessments closer to real-time.

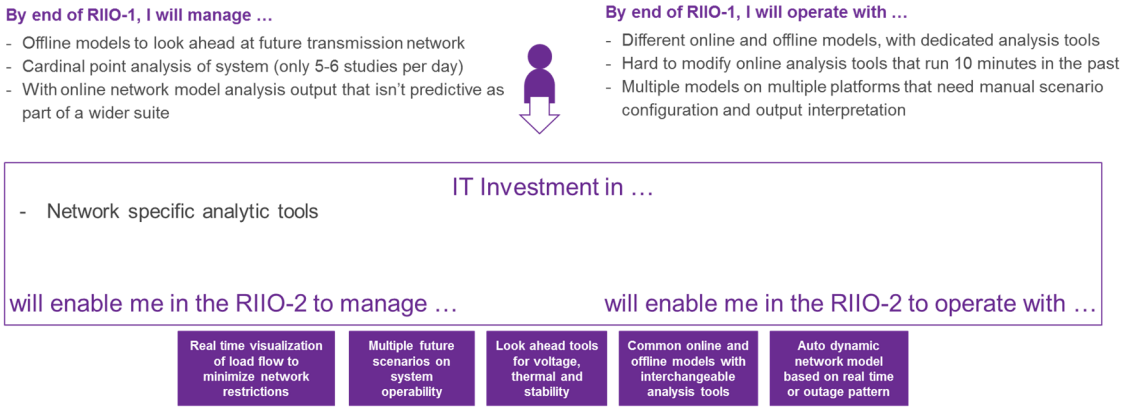

Figure 12 - Use case, investment and outcome expectation

2.4.4 Roadmap

This investment includes implementation of:

- an additional state estimator that operates closer to real-time to provide a high-level analysis of the network
- closer to real-time look ahead power flow capability that builds on the current Day Ahead Congestion Forecast (DACF)
- improved voltage stability assessment as the current tool only provides a restricted view of where we are on a voltage stability curve

- voltage flight path capability which provides real-time Mega Volt Amps reactive (MVAr) dispatch advice.

All these tools will be prioritised and delivered throughout the RIIO-2 period based on industry and operational priorities.

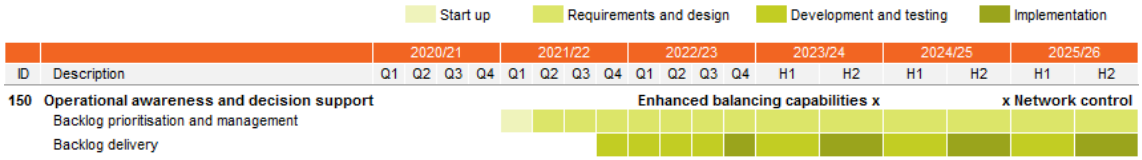

Figure 13 – Delivery plan

2.4.5 Future state

Enhanced look ahead capability will be required to predict transmission problems in a more volatile operating environment.

Apart from new tools or enhancements to current tools, we will need greater alignment between real-time online and offline tools to allow for a more efficient control centre operation. These tools will be integrated via the IT investment 220 Data and analytics platform (arrows reflect data flows):

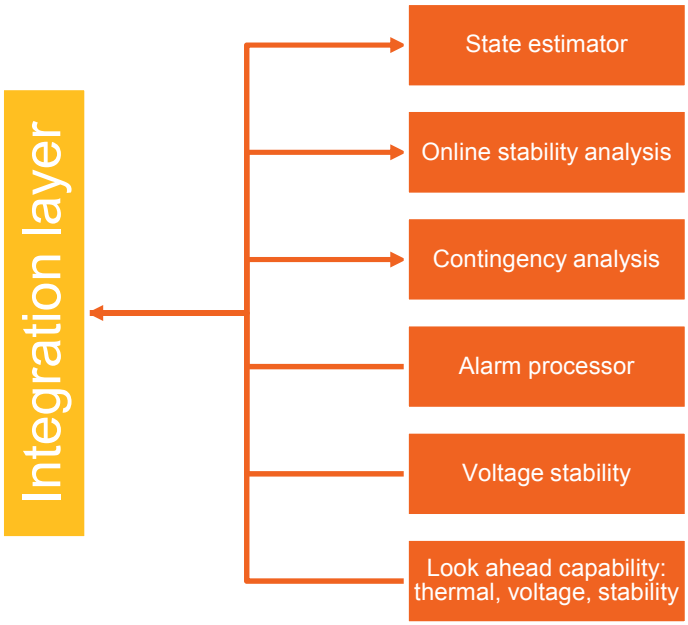

Figure 14 – Data flow integrations

2.4.6 Approach

We will take a similar approach to IT investment 110 Network control.

We will develop operational modelling and scenarios analysis tools. These will capture, store, analyse, and present data from multiple new sources in real time.

These rely heavily on IT investment 220 Data and analytics platform which will be the foundation to meet the needs of the RIIO-2 programme. The artificial intelligence and machine learning methods it enables will then be used to recommend or automatically execute actions.

2.4.7 Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	0.4	1.7	3.4	3.8	1.7	**11.1**
Opex	0.0	0.2	0.4	0.4	0.2	**1.2**
Total	**0.5**	**1.9**	**3.8**	**4.3**	**1.9**	**12.3**
Cumulative RTB* increase	0.0	0.0	0.1	0.2	0.3	**0.5**

Gartner benchmark range	
Low	15.0
High	20.0

*RTB - run-the-business on-going opex

Figure 15 - investment costs

We expect investment synergies with IT investments 220 Data and analytics platform and 110 Network control to keep the costs associated with this investment line below Gartner's benchmark.

2.4.8 Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
It may prove difficult to achieve a common dataset for all modelling requirements or have the right data quality accessible to achieve new tools full potential. This may increase cost due to more complex implementation.	• Understand data needs early in project. • Work with stakeholders, including the Government's Data Task Force and DSOs, to ensure the ESO has access to relevant data. • Engage with other European system operators to ensure consistent operating regimes and reliability standards implementation across Europe as well as availability of consistent data sources or modelling. • Data strategies to be considered in RIIO-1 to ensure we understand the necessary data requirements (quality criteria) to enable an effective transition into RIIO-2. • Have data stewards and a data centric culture supported by data management tools in data and analytics platform. • Engage closely with the business and monitor	2	1

Risk	Mitigation(s)	Likelihood	Impact
	development of the whole system approach. • Utilise the design authority to drive industry consensus.		
System/market conditions change too quickly to be accommodated, rendering tools ineffective.	• Investigate dependencies in start-up phase of project. • Ensure IT tools are configurable and adaptable.	3	1

2.4.9 Options

Option(s)	Pros	Cons
Not invest in this area		• Increases operational risk. • Increases cyber security risk. • Puts at risk 2025 ambition to be able to operate a carbon free electricity system. • Increases inefficient decision-making and associated operational costs. • Does not enable transparency of operational actions.
Invest in legacy tools		• Does not enable investment scalability. • Puts at risk 2025 ambition to be able to operate a carbon free electricity system. • Increases the risk that current tools aren't fit for purpose in a changing energy landscape. • Does not support transparency of operational actions.
Update tools and integrate with data platform, network control and enhanced balancing capability	• Supports 2025 ambition to be able to operate a carbon free electricity system. • Ensures tools remain fit for purpose in line with industry changes. • Enables investment scalability.	

Option(s)	Pros	Cons
	• Enables introduction of efficient processes. • Improves operational decision-making.	

2.5. 170 Frequency visibility

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

2.5.1 Overview

To maintain control of the power system, ESO must monitor system frequency at high resolution in real time.

Frequency monitoring is also critical for system restoration in a black start situation.

2.5.2 Current state

Our frequency monitoring capability is provided by a bespoke system, known as Frequency and Time Error (FATE). This system collects frequency information from a limited number of locations on the transmission network. Due to the critical nature of this data, FATE is a critical national infrastructure (CNI) system.

This is supplemented by a GE Phasorpoint system which provides additional information and situational awareness of regional variations in frequency and stability. It receives information from phasor measurement units (PMUs), which are being rolled out by the TOs. This system is currently a standard business system.

2.5.3 Case for change

As the amount of distributed generation increases, changes will be needed in the way the transmission system is monitored in real time. Purely monitoring frequency is no longer sufficient and we will need more information on regional conditions to maintain stability. We will also need better capability to monitor emerging issues such as harmonics and flicker. The TOs are continuing to roll out PMUs and accessing data from these will greatly enhance our capability to monitor the state of the system. We will be processing ever greater amounts of data.

This investment will maintain and improve the ability of the control centre to manage frequency and inertia and understand the effects of system events with confidence.

2.5.4 Roadmap

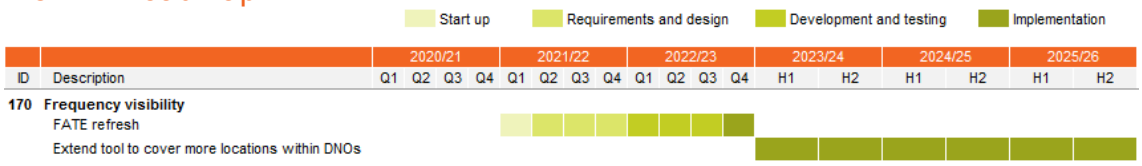

Figure 16 – Delivery plan

2.5.5 Future state

This investment will keep the FATE system operational and extend it to cover more locations in the DNO networks.

We will enhance its capability to monitor and assess PMU data and address new challenges. As this will be critical for us, we plan to transfer it to the CNI environment to increase its reliability and security.

This investment will also underpin IT investments 130 Emergent technology and system management and 500 Zero carbon operability, for inertia monitoring and wide area monitoring and control system respectively.

2.5.6 Approach

We will continue to invest in the maintaining and enhancing the FATE system and will integrate it more closely with the PMU monitoring capability. As noted above, we will also transfer the PMU monitoring capability to the CNI environment to increase reliability and security.

2.5.7 Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	0.6	0.6	0.2	0.2	0.2	**1.6**
Opex	0.1	0.1	0.0	0.0	0.0	**0.2**
Total	**0.6**	**0.6**	**0.2**	**0.2**	**0.2**	**1.8**
Cumulative RTB* increase	0.0	0.0	0.0	0.0	0.0	**0.1**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	1.6
High	1.9

Figure 17 - investment costs

Cost estimates for this investment line are based on previous refresh and data expansion activities of this specific tool.

2.5.8 Risks

No specific risks have been associated to this investment. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

2.5.9 Options

Option(s)	Pros	Cons
Not invest in this area		• Puts our capability to manage system frequency at risk. • Increases cyber security risk. • Leaves an operational critical tool unsupported
Perform tool refresh but not expand its data points	• Addresses cyber security risk.	• Puts our capability to manage system frequency at risk.
Update tool and extend data points	• Addresses cyber security risk. • Addresses our capability to manage system frequency risk.	

2.6. 180 Enhanced balancing capability

Current stage:

Scoping	Start-up	Requirements and design	Development and testing	Implementation

2.6.1 Overview

Our core balancing systems enable the real-time balancing of electricity supply and demand and are classed as critical national infrastructure (CNI). A major failure of these systems would result in widespread loss of supply, which would lead to economic and societal damage to the UK and put ESO's licence at risk. It is essential that we invest in our core balancing systems to manage the rapidly evolving electricity market. We will also deliver training simulation tools combined with artificial intelligence and digital twin technology relevant to this investment.

2.6.2 Current state

The core balancing capability is currently provided by a hybrid solution of the electricity balancing system (EBS) for scheduling, a balancing mechanism (BM) for dispatch of balancing mechanism units (BMUs) and ASDP for ancillary services dispatch of non-BMUs. This is supplemented by the contingency logging system (CLOGS) which provides a rudimentary business continuity capability during planned or unplanned outages of the core systems. Most of these systems were designed against a traditional landscape of large transmission connected generation.

Currently we make around 200 instructions every hour. We expect this to double over the next few years due to wider access delivered through project TERRE, discussed in Themes 1 and 2. Having to handle this volume of instructions means the new balancing capability will need to be more flexible and more agile than today.

By the end of RIIO-1 we expect the main balancing system landscape to look like this:

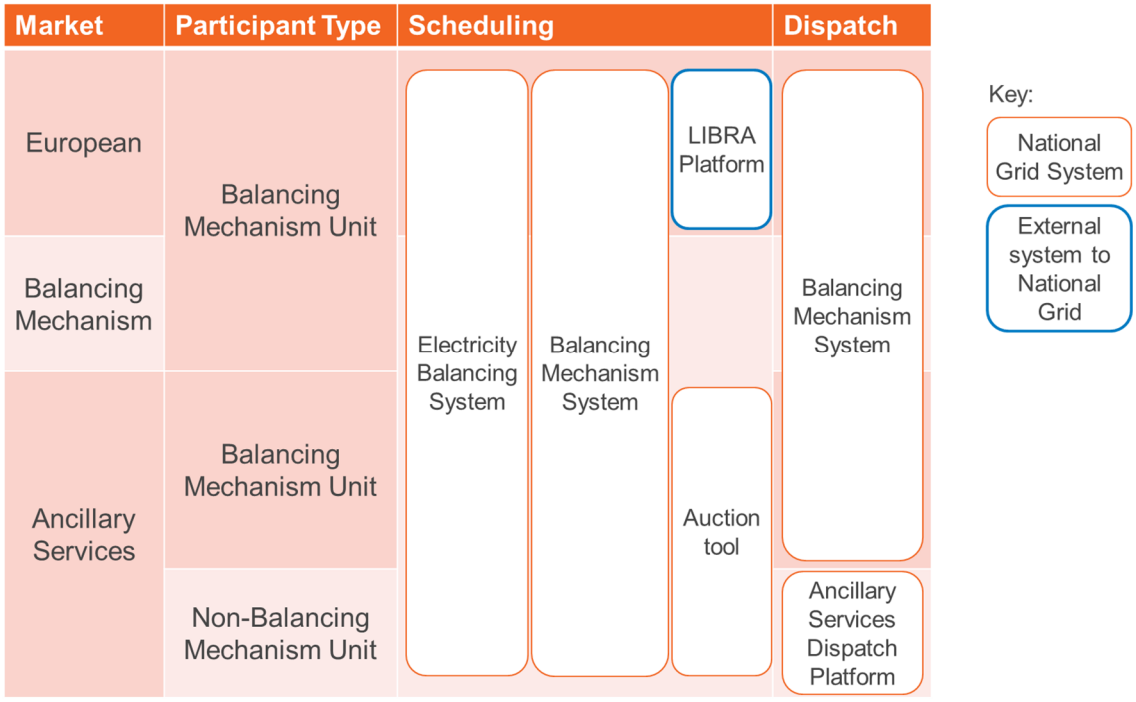

Figure 18 – Anticipated balancing system landscape

2.6.3 Case for change

By 2023, a level playing field for all market participants 1 MW and above will require a new way to plan and dispatch participants to maintain system security. The balancing system will be dealing with more data from more providers and managing more actions and market interactions.

The image below shows the high-level decision process to dispatch one market participant. There are currently around 2,000 BMUs. These will increase as the market decentralises, and an engineer needs to consider not just impacts on the transmission network but also on the distribution ones. Decision-making complexity is expected to increase exponentially, and will be made in much shorter timescales, demonstrating the need for artificial intelligence and machine learning to continue to balance the network safely and economically.

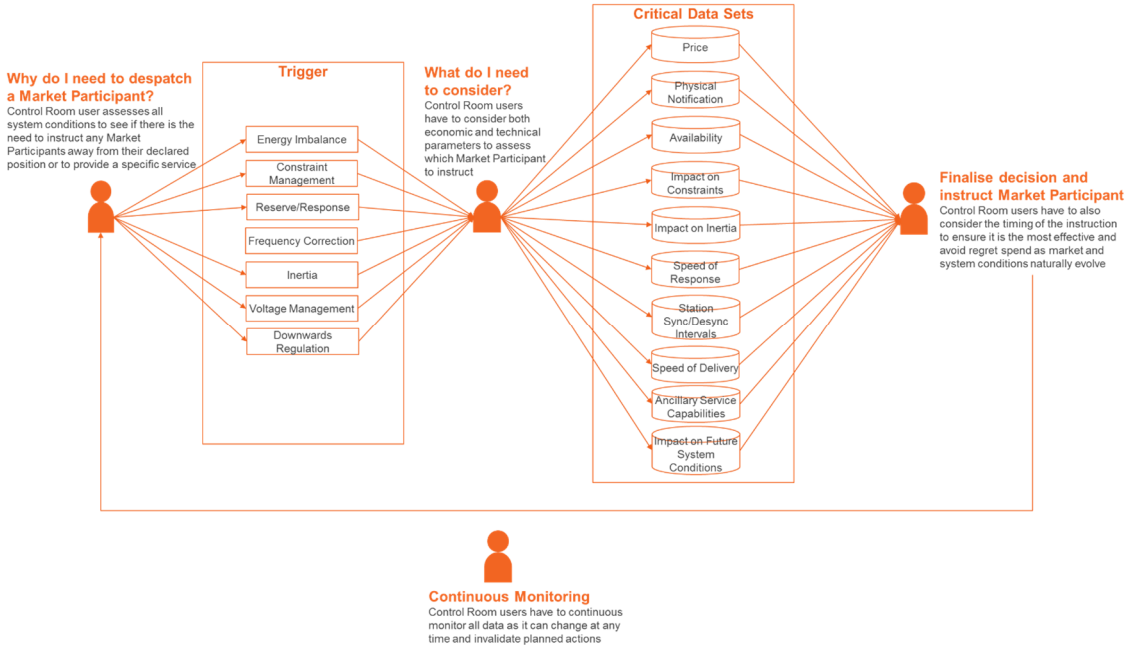

Figure 19 – High-level decision process for control centre engineers

The capabilities we invest in will have to allow control centre users to manage various RIIO-2 challenges as shown below:

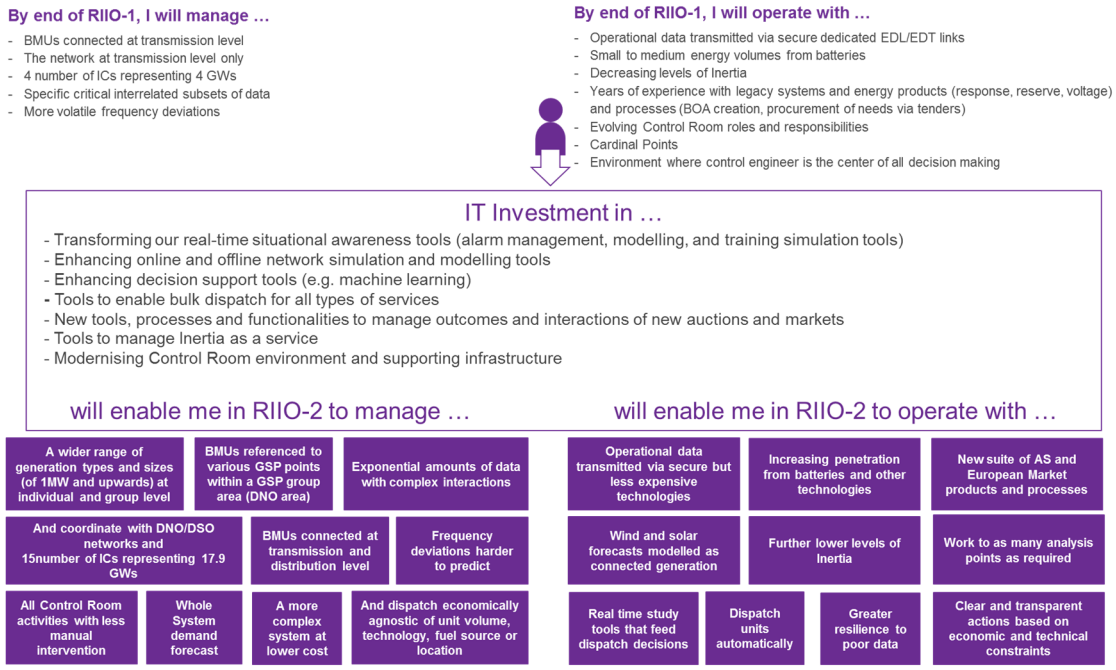

Figure 20 - Use case, investment and outcome expectation

2.6.4 Roadmap

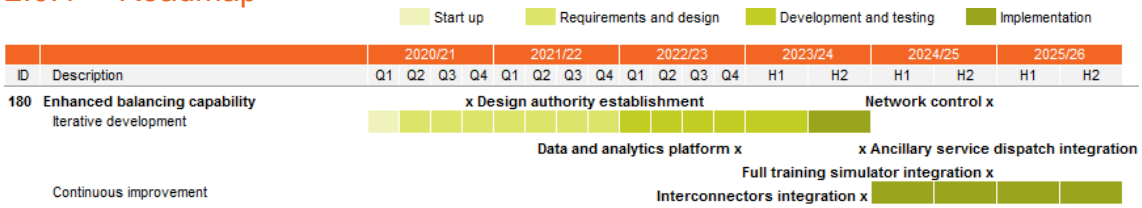

Figure 21 – Delivery plan

2.6.5 Future state

We will enhance our core balancing capability both in terms of systems and processes, in a modular fashion, during RIIO-2. We assume CLOGS functionality will become part of the core balancing capability and its use no longer needed given investment in dual resilience.

We will make better use of data by integrating these capabilities with IT investment 220 Data and analytics platform and apply machine learning and automated control to transform system balancing. This will underpin other IT investments, like 120 interconnectors and 130 Emergent technology and system management and allow us to add balancing simulation into future training simulators.

We will develop our core balancing systems and processes in a modular fashion to deliver dispatch and scheduling improvements. Our scheduling solution will be in line with the market gate closure[1], flexible for any market change, including a new suite of ancillary services, and close to real time auction markets.

Our main specific electricity systems have bespoke components and are developed in house or with specialised partners. We do this, so we have not just reliable, but also flexible updates at market pace in a cost-effective way.

[1] The point where companies can no longer trade electricity for a designated 30-minute period (a settlement period). Gate closure is currently one hour before the start of the settlement period.

2.6.6 Approach

We will build new balancing market optimisers using a proven mathematical optimisation package.

These will be developed to run in a range of situations to satisfy the necessary live, simulated, test and analytical scenarios.

We will go to the market for the trialling, development and integration of the new optimisers. In parallel we will grow our in-house mathematical optimisation capability to manage the optimisers once the system is live.

The new optimisers will be exhaustively tested to ensure they perform well beyond the projected parameters before committing to their full development.

The new optimisers will sit in the ESO service-oriented architecture (SOA) to give real time input and output.

In simulation, training, test, and analytical modes, the new optimisers will be driven by a discrete event simulation package to simulate real time inputs for the system combined with live data. This will be complemented by test data packs and extract transform load (ETL) processes (i.e. bulk data processes) to automate the capture and adjustment of live data.

2.6.7 Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	8.1	10.1	12.2	6.1	4.1	**40.5**
Opex	0.9	1.1	1.4	0.7	0.5	**4.5**
Total	**9.0**	**11.3**	**13.5**	**6.8**	**4.5**	**45.0**
Cumulative RTB* increase	0.2	0.2	0.3	0.4	0.4	**1.5**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	27.0
High	44.0

Figure 22 - investment costs

Our proposal is just above Gartner's higher range. Lower and higher value gap is due to limited comparative data for our specific requirements. Given the critical nature, ambition and complex level of change around this area we decided to keep our proposal.

2.6.8 Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
High impact market and regulatory (EU and GB) changes do not enable the new tool development to progress as intended. This could lead to key resources and attention being deviated to handle short term compliance implementation delaying strategic tool delivery.	• Develop new tool offline and with different resources than the ones delivering short term compliance changes. • Engage all stakeholders via design authority to try and keep the level of high impact changes to the	1	

Risk	Mitigation(s)	Likelihood	Impact
	minimum necessary in initial stages of the project.		
System complexity leads to long development and implementation periods.	• Apply lessons learnt from previous projects, both positive and negative. • Adopt agile delivery methodologies to give the market as much value as early as possible. • Adopt modular approach to development of new capabilities. • Develop system offline so that critical market changes can still go ahead in legacy systems and new system development can also progress as planned.	2	

2.6.9 Options

Option(s)	Pros	Cons
Not invest in this area		• Creates operational risk, staff overheads and technical debt as it addresses balancing problems with inefficient processes and workarounds. • Increases cyber security risk. • Does not support transparency of our operational actions. • Does not support investment scalability and flexibility. • Puts at risk 2025 ambition to be able to operate a carbon free electricity system. • Leaves critical tools unsupported. • Puts responding to regulatory changes at risk.
Invest in legacy tools		• Requires refresh of current tools. • Does not support investment scalability and flexibility. • Restricts pace of to align to industry changes. • Increases risk of delivering changes timely and efficiently.

Option(s)	Pros	Cons
		• Risk of not being able to retain or attract legacy skill resourcing/SME.
Update tools and integrate with data platform, network control and markets platform	• Enables introduction of flexible and scalable tools aligned with industry changes. • Supports transparency of our operational actions. • Introduces delivery efficiencies. • Supports easy and economic data sharing with our customers. • Enables 2025 ambition to be able to operate a carbon free electricity system.	

2.7. 120 Interconnectors

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

2.7.1 Overview

The amount of interconnection to other transmission systems and/or internal high voltage direct current (HVDC) links are expected to steadily increase over the remainder of the RIIO-1 period and throughout RIIO-2. To manage this, our current tools and processes will need to be extended to handle the additional capacity and data complexity.

2.7.2 Current state

Each new interconnector added to the transmission system requires changes to many legacy systems. Interconnector implementation affects balancing mechanism (BM) systems including EBS and SPICE, reporting systems (such as MODIS), interconnector data exchange (IDX) and the ancillary services (AS) settlements system.

2.7.3 Case for change

During RIIO-2 we need to be prepared to implement seven new interconnectors, meaning that interconnectors could meet half of GB system demand overnight.

Current interconnector implementation is inefficient due to legacy systems and architecture configuration. Given their operational criticality, enhanced visualisation and management capabilities must be developed as part of this investment.

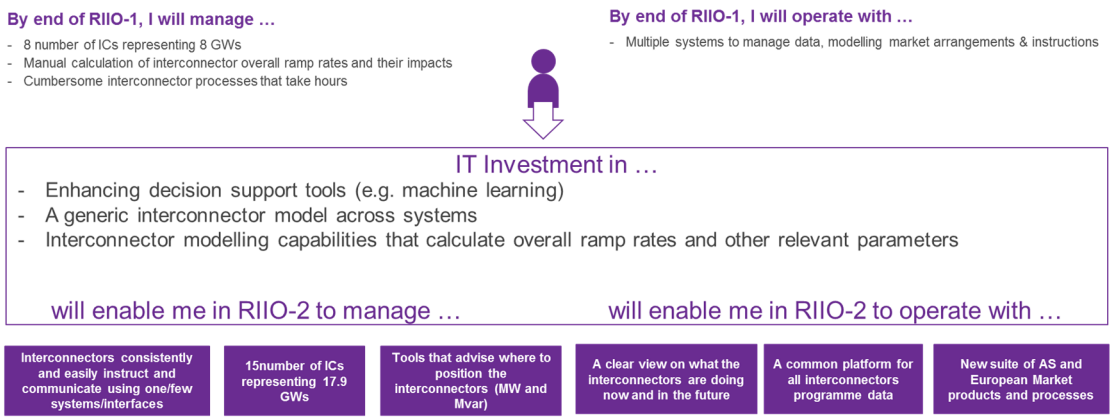

Figure 23 - Use case, investment and outcome expectation

2.7.4 Roadmap

All interconnector go live dates are our estimations based on current information. These can move before and even during the RIIO-2 period. Regardless, our main investment in interconnector management tools will continue to be integrated with our enhanced capabilities to deliver market benefits and efficiencies.

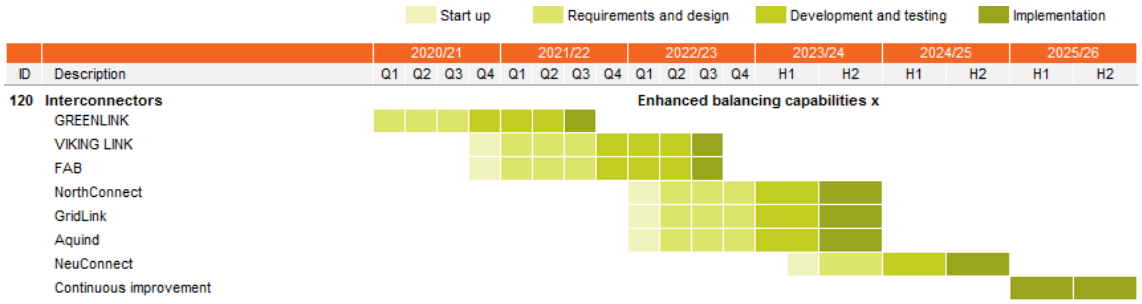

Figure 24 – Delivery plan

2.7.5 Future state

New interconnectors will become part of our future IT investment 180 Enhanced balancing capability to give us the flexibility and agility to deliver all new interconnectors in a standardised and economical way.

We will use the same approach as for enhanced balancing capabilities to give the best outcome for both the ESO and the industry. This investment will enable interconnectors to be used to their full potential but also improve implementation times. Through RIIO-2 we will reduce costs to introduce new interconnectors or enabling them to participate in new balancing services.

Improvements will mostly be visible after 2023/24 as benefits of this investment rely on IT investments 180 Enhanced balancing capability and 220 Data and analytics platform work.

2.7.6 Approach

We will develop application components to add network resources, including interconnectors, in a low cost and repeatable way.

Existing application components will be enhanced to automate the addition of new interconnectors.

The capabilities added by the data and analytics platform and the digital experience platform will allow us to configure and automatically integrate new applications into existing applications.

2.7.7 Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	1.5	1.5	0.7	0.7	0.5	**5.0**
Opex	0.2	0.2	0.1	0.1	0.1	**0.6**
Total	**1.7**	**1.7**	**0.8**	**0.8**	**0.6**	**5.5**
Cumulative RTB* increase	0.0	0.1	0.1	0.1	0.1	**0.5**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	4.3
High	5.0

Figure 25 - investment costs

Although Gartner benchmark range is lower than our cost proposal, we have derived our costs from previous and current interconnector implementation projects, including efficiencies predicated on other investment lines. As such, we have left our costs at the present level.

2.7.8 Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
Interconnectors implementation dates are moved forward or back.	Review our assumptions regarding the number of interconnectors expect to be implemented during RIIO-2 for every two-year plan.	6	1

2.7.9 Options

Option(s)	Pros	Cons
Not invest in this area		• Does not allow for new interconnectors. • Restricts GB and European market benefits. • Puts at risk 2025 ambition to be able to operate a carbon free electricity system.
Invest in legacy tools		• Inefficiencies between the enhanced balancing capabilities and the interconnector management legacy systems aren't addressed. • Does not facilitate easy or economic data share leading to lack of transparency. • Puts at risk 2025 ambition to be able to operate a carbon free electricity system. • Does not allow for improvement in implementation times of new interconnectors from 2024/25.
Update tools and integrate with data platform and enhanced balancing capabilities	• Enables efficient processes. • Enables efficient sharing data with our customers. • Allows implementation time improvements of new interconnectors from 2024/25.	

2.8. 190 Workforce and change management tools

Current stage:

Scoping	Start-up	Requirements and design	Development and testing	Implementation

2.8.1 Overview

This investment will make learning and operational updates available on different platforms and adjusted to user's profile, giving better training and operational decision-making. New tools will support shift, change, contract and document management, plus workforce planning.

2.8.2 Current state

Currently control centre users are updated on operational issues or policy changes using legacy tools or paper-based processes. This means users, who can perform multiple roles, receive updates that do not relate to the job they are performing on a given day.

Lack of flexibility means shift management options are also limited.

2.8.3 Case for change

With the increased use of new technologies and more frequent update to policies and standards, our current processes and tools will become inefficient and potentially introduce risks.

The legacy tools used to manage change in the balancing mechanism system and shift management will require refresh or replacement during the RIIO-2 period. This gives us the opportunity to automate our processes and ensure the right updates are given to our control centre users at the right time and in an appropriate format.

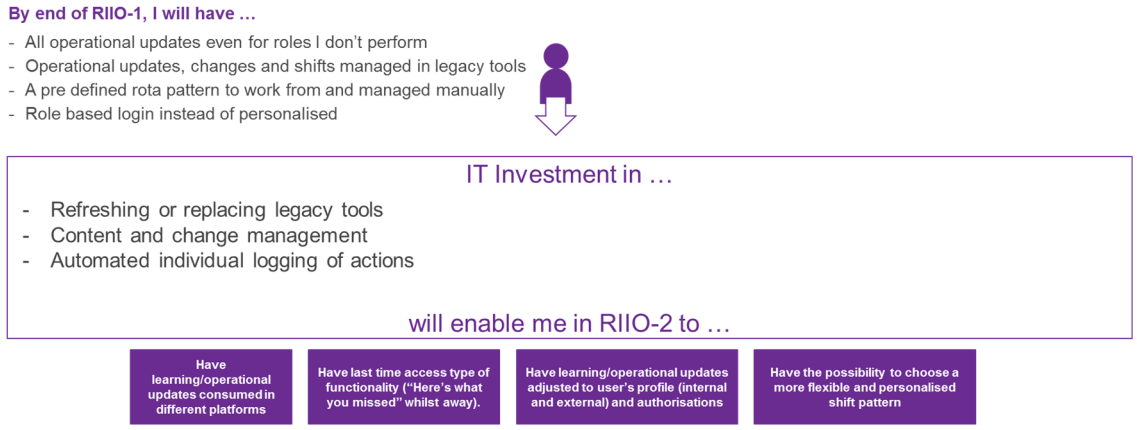

Figure 26 - Use case, investment and outcome expectation

2.8.4 Roadmap

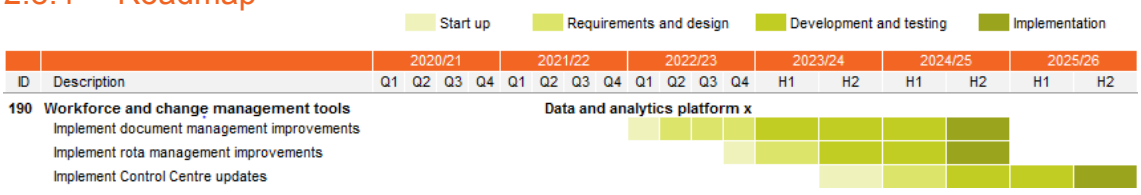

Figure 27 – Delivery plan

2.8.5 Future state

We will integrate these management tools with our IT investments 180 Enhanced balancing capability and 110 Network control tools to enable personalised updates. They

will be linked to the rota and change management tools to allow for relevant updates to be given as required, for example, when a control centre user returns from a day off to perform a specific role.

Automation of workforce related processes will allow for more flexible rota planning as well as ensuring all users have the most up to date information to do their job.

2.8.6 Approach

We will follow a best of breed approach - we will select and buy the necessary workforce management, planning, and skills management tools to build a modern workforce management solution.

We will use the capabilities of the data and analytics platform to integrate components into the necessary directory, HR, and ERP systems.

We will implement in the public cloud where we can.

2.8.7 Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	0.0	0.0	0.0	0.0	0.0	**0.0**
Opex	0.0	0.4	0.8	1.2	1.6	**4.0**
Total	**0.0**	**0.4**	**0.8**	**1.2**	**1.6**	**4.0**
Cumulative RTB* increase	0.0	0.0	0.0	0.1	0.1	**0.2**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	4.0
High	6.0

Figure 28 - investment costs

Our costs for this investment line are predicated in RIIO-1 work we are making in this area and synergies with other RIIO-2 IT investments like 220 Data and analytics platform.

2.8.8 Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
Specific investments delivering control centre toolset fail to deliver suitable associated login and recording capabilities.	Ensure training teams are engaged in relevant projects from early on and feed their requirements in.	2	1

2.8.9 Options

Option(s)	Pros	Cons
Not invest in this area		• Increases risk of not being able to retain or attract skilled workforce. • Prevents efficient development of current workforce. • Introduces operational risk. • Puts at risk 2025 ambition to be able to operate a carbon free electricity system.
Invest in legacy tools		• Increases operational risk. • Introduces inefficiencies in our compliance processes. • Prevents efficient development of current workforce. • Does not facilitate easy and cost-effective data share with our customers. • Puts at risk 2025 ambition to be able to operate a carbon free electricity system.
Update tools and integrate with data platform and enhanced balancing capabilities	• Ensures cyber security compliance. • Facilitates transparency of our actions. • Enables flexible and efficient compliance and regulatory processes. • Supports 2025 ambition to be able to operate a carbon free electricity system.	

2.9. 200 Future training simulator

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

2.9.1 Overview

This investment covers the implementation of a control centre training simulator for both internal and external use, covering training for refresher and upskill sessions, special events, introduction of changes, feedback and authorisation exams.

2.9.2 Current state

Currently a large amount of training takes place through ‘shadowing’, where new control centre users shadow more experienced ones.

Offline training is also available but only for certain roles or scenarios.

2.9.3 Case for change

Having a full suite of tools that allow for full team training and offline training will not just lead to better prepared control centre users making better decisions but will do so in a consistent and cost-effective way. It increases the likelihood that talented staff will stay with us.

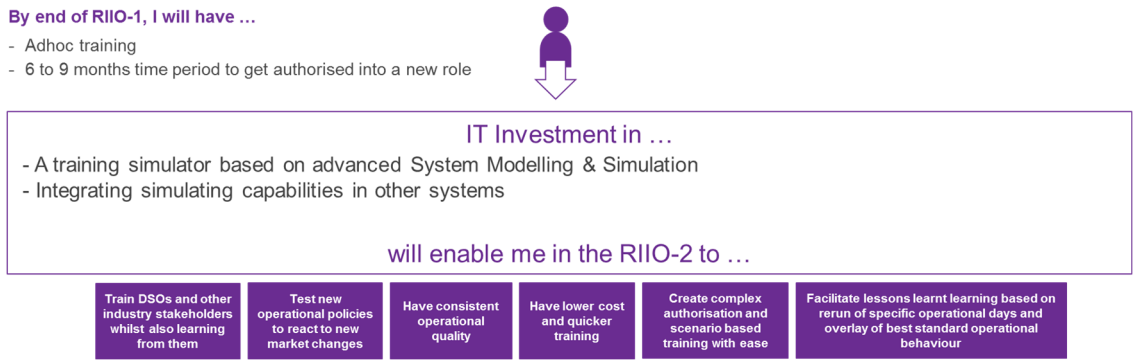

Figure 29 - Use case, investment and outcome expectation

2.9.4 Roadmap

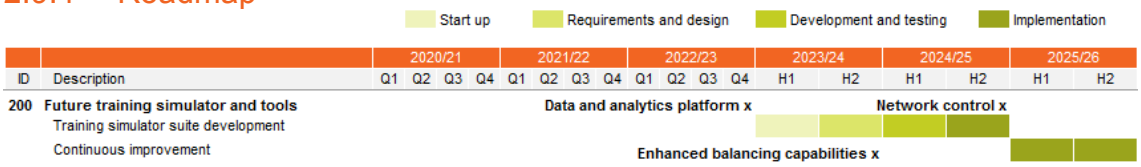

Figure 30 – Delivery plan

2.9.5 Future state

We will use our new simulation capabilities to deliver a training suite that includes end-to-end scenario simulations. The training simulator will also integrate capabilities from IT investment 400 single markets platform to easily create complex scenarios.

The same capabilities can be used to use different data sets and train DSOs and other industry stakeholders, if such need arises, as well as our own teams.

2.9.6 Approach

We will simulate operational systems in a data environment to train operators and aspiring operators.

The approach follows key aspects of enhanced balancing capability.

Operational system replicas will be driven by an event simulation package to generate simulated real time inputs. This will be complemented by test data packs and ETL processes (extract-transform-load i.e. bulk data processes) to automate the capture and adjustment of live data for training.

We will build simulation automated management tools to allow trainers to control the scenario presented to trainees and to measure their performance.

We will use cloud technology to provide the capacity to host multiple separate instances and datasets simultaneously for relatively short periods of time. New operational systems (e.g. the new optimisers) will be cloud native to simplify and lower their cost.

2.9.7 Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	0.0	0.0	1.2	2.3	2.3	**5.8**
Opex	0.0	0.0	0.3	0.6	0.6	**1.5**
Total	**0.0**	**0.0**	**1.5**	**2.9**	**2.9**	**7.3**
Cumulative RTB* increase	0.0	0.0	0.0	0.1	0.2	**0.3**

*RTB - run-the-business on-going opex

Gartner benchmark range

Low	4.0
High	8.1

Figure 31 - investment costs

Costs for this investment line were estimated based on the number of potential users and complexity of training and simulation needs, spanning from operational to market behaviour scenarios. Cost synergies were considered between IT investments 110 Network control, 180 Enhanced balancing capability and 400 single markets platform.

2.9.8 Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
Training infrastructure needs additional IT investment.	• Investigate dependencies in start-up phase of project. • Ensure IT tools are configurable and adaptable.	2	1
The complexity of ESO activity increases leading to current training toolset not allowing us to train control centre users effectively.	• Monitor training needs closely as the industry evolves in next few years and reprioritise investment plans if required.	3	
Specific investments delivering control centre tools fail to deliver suitable associated training simulation tools.	• Ensure training teams are engaged in relevant projects from early on and feed their requirements in.	2	2

2.9.9 Options

Option(s)	Pros	Cons
Not invest in this area		• Prevents efficient development of current workforce. • Introduces operational risk. • Puts at risk 2025 ambition to be able to operate a carbon free electricity system.
Invest in legacy tools		• Prevents efficient development of current workforce. • Introduces operational risk. • Puts at risk 2025 ambition to be able to operate a carbon free electricity system.
Update tools and integrate with data platform and enhanced balancing capabilities	• Enables training and testing of possible future scenarios. • Adds ability to have training and operational efficiencies with DNOs. • Introduces operational consistency. • Enables transparency of post-event analysis. • Supports 2025 ambition to be able to operate a carbon free electricity system.	

2.10. 220 Data and analytics platform

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

2.10.1 Overview

This is foundational work to unlock the value of the data we hold. It will be the key technology underpinning all our internal and external data management, pulling together data from a variety of sources and ensuring there is only one source of the truth. This includes CNI and non-CNI data and analytics platforms as well as their associated integration platforms.

Cloud-based data management and analytics are now universal and essential for modern data analysis approaches and even more so for artificial intelligence implementations. This investment will evolve ESO's traditional data management and analytics to the cloud. It is indispensable for much of the RIIO-2 change programme, including unlocking the value of our digital twin technology investments and hosting data from the asset register, fundamental for our single markets platform.

2.10.2 Current state

We currently have a few systems to store data for analysis and reporting. These are being upgraded to handle more data that will result from the changing regulatory frameworks and the increase in market participants.

We also have a system to distribute incoming regulatory reporting files.

During RIIO-1, a core set of integration systems have been implemented on non-CNI infrastructure to enhance our flexibility. We are now using a service-oriented architecture (SOA) approach for system interfaces which is reducing complexity and streamlining the data transfer between systems.

The ESO has started to offer application programming interface (API) access to data and services (such as the carbon intensity API) which allows partners and customers to access information or unlock value by building on existing services. It also offers fast and secure access to data, allowing seamless expansion of business capabilities into the cloud and coordinating in house with external solutions.

2.10.3 Case for change

The ESO has regulatory obligations to report on balancing activities, both to the GB and European markets. We need to maintain the appropriate systems and expand them to accommodate the increased number of participants. Accurate and timely information is vital to the market for customers to manage their positions.

We anticipate that the volumes of data managed by the ESO will continue to increase significantly in a short timescale because of greater market participation, from both a European and GB regional perspective. Closer coordination with DSOs will also increase the volume and types of data. We need solutions that can increase in scale.

To achieve this, we plan to replace our current storage and reporting systems with solutions integrated within a data and analytics platform. This also leads to a need for master data management tools and analytics packages that allow users to unlock the real value of our data.

This same increase in complex interactions drives the need to use digital twin technology (enabled through this investment) of each new strategic system during RIIO-2 to enable a quick analysis of ways to manage new challenges and avoid unnecessary spend, as explained under Theme 1.

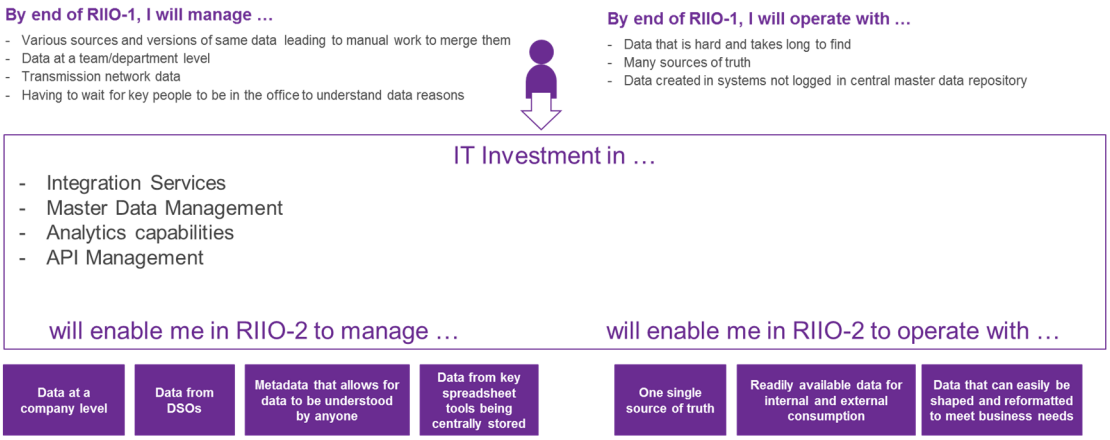

Figure 32 - Use case, investment and outcome expectation

2.10.4 Roadmap

Our immediate focus in year one of RIIO-2 will be to build the foundations of our data and analytics platform and share as much data as possible in machine readable format. We will work through our data, following on from work during RIIO-1, making the highest priority data available first.

This work will be integrated with the digital engagement investment to ensure we present all data in consistent and efficient formats across the whole of the ESO to meet our RIIO-2 ambitions.

Our SOA approach will continue to be enhanced in RIIO-2 and will be extended into the CNI area, as new tools are delivered.

The significant increase in the volume and complexity of data will require a master data management system in place early in RIIO-2, with asset refresh at the end of the period.

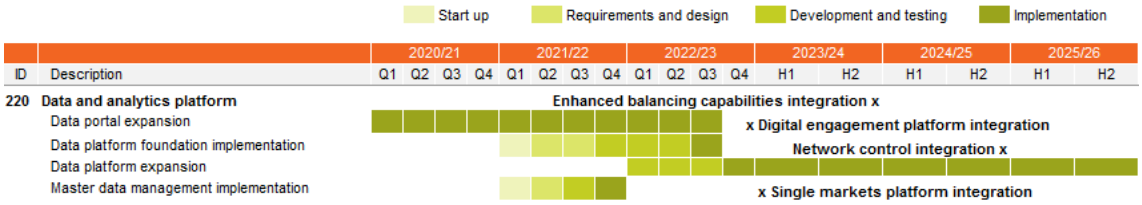

Figure 33 – Delivery plan

2.10.5 Future state

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 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.

2.10.6 Approach

We will progressively develop the new data and analytics platform to meet the needs of the RIIO-2 programme, delivering common capabilities for the component projects of the programme.

By default, the data and analytics platform will use low cost, open source, commodity building blocks and standards and give maximum flexibility for participants.

We will choose new solution components only after careful consideration and appropriate selection processes.

We will modernise existing data management and analytical capabilities that are still fit for purpose.

We will institute a pragmatic data architecture and governance regime, supported by the right tools. Participants will have access to our metadata to provide reliable integration with ESO systems.

We will draw on external partners' capability and capacity during implementation of the data and analytics platform, and we will develop deep in-house capabilities for the RIIO-2 programme and beyond. The data science and analytical skills enabled by the data and analytics platform (and attendant capabilities, notably multiple forms of artificial intelligence) are core to the ESO role.

The platform will be primarily cloud-based with deployment to CNI-compliant hybrid cloud as well as public cloud for less critical workloads. Public cloud opens further options for participants to ESO datasets.

Major component technologies will be subject to detailed selection processes to ensure that all requirements are met reliably. Careful selection will avoid unnecessary duplication of capabilities and reduce build and run cost.

The data and analytics platform will sit in the ESO SOA to standardise and automate access for the RIIO-2 business service. We will extend the ESO SOA to participants as managed APIs permitting access to ESO (tightly controlled) data and analytics services in the most cost-efficient way that meets industry standards.

2.10.7 Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	3.1	5.8	5.8	3.1	2.2	**20.0**
Opex	0.8	1.5	1.5	0.8	0.5	**5.0**
Total	**3.8**	**7.3**	**7.3**	**3.8**	**2.7**	**25.0**
Cumulative RTB* increase	0.0	0.1	0.3	0.5	0.6	**1.4**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	23.0
High	27.6

Figure 34 - investment costs

Expectations of costs for this investment line fall within Gartner's range and provide synergies for other RIIO-2 investments.

2.10.8 Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
It may prove difficult to achieve a common dataset for all modelling requirements, leading to increase cost due to more complex implementation.	• Have data stewards and a data centric culture supported by data management tools in data and analytics platform.	2	2

2.10.9 Options

Option(s)	Pros	Cons
Not invest in this area		• Prevents easy and economic data sharing with our customers. • Creates operational risk, staff overheads and technical debt as it addresses data problems with inefficient processes and workarounds. • Requires higher level of investment in other areas to make up for data inefficiencies. • Does not allow for Theme 1 and 2 proposals to be delivered. • Does not enable transparency of our actions. • Prevents reacting to new customer data needs in a timely way.
Invest in legacy tools		• Does not enable easy and economic data sharing with our customers. • Does not allow for scalability of investment. • Duplicates investment in other areas to make up for lack of data standards. • Does not allow for Theme 1 and 2 proposals to be delivered. • Introduces inefficiencies as different standards get used to address data problems. • Does not support transparency of our actions. • Prevents reacting to and meeting new customer data needs in a timely way.

Option(s)	Pros	Cons
Update tools and integrate with data platform, network control, digital engagement platform and enhanced balancing capabilities	• Enables transparency of our actions. • Enables easy and economic data sharing with our customers. • Allows for scalability of investment. • Supports objectives of other prioritised costumer value areas in RIIO-2 plan. • Introduces data standards and efficient management. • Enables quicker and better operational decisions.	

2.11. 450 Future innovation productionisation

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

2.11.1 Overview

This is investment to introduce yet unplanned innovation projects for future IT systems into full operation.

2.11.2 Current state

As we move into RIIO-2, we expect innovation allowances will continue (potentially in a different format). The rules of the innovation allowances do not allow for putting IT systems into full operation (known as 'productionisation') at the end of the trial period.

2.11.3 Case for change

We expect a proportion of future innovation projects will identify an enduring benefit to the consumer or to the business and will need to be productionised into the IT estate. We include a conservative estimate for these investments, which ramps up towards end of the RIIO-2 period.

2.11.4 Roadmap

Innovation projects will be assessed for productionisation on a case by case basis.

2.11.5 Future state

This investment covers future Network Innovation Allowance (NIA) projects only. This funding is needed to enable us to respond to challenges as they appear. The ongoing nature of the NIA pipeline requires funding to be available for NIA productionisation. We are evaluating several projects that would mature towards the end of the RIIO-1 period and may require funding early in RIIO-2.

This investment also includes an opex element to cover IT support for new innovation projects.

Known Network Innovation Allowance (NIA) and Network Innovation Competition (NIC) projects are covered by their own investment lines, included elsewhere in the RIIO-2 submission:

- productionisation of the Enhanced Frequency Control Capability (EFCC) project is included under IT investment 500 Zero carbon operability
- productionisation of the Firm Frequency Response (FFR) auction trial is included under IT investment 420 Auction capability
- productionisation of the Distributed ReStart restoration project is covered under IT investments 460 Restoration and 510 Restoration decision support
- productionisation of Power Potential is covered under IT investment 340 RDP implementation and extension.

There are currently no new NIC bids in the pipeline. The next submission opportunity is at the end of 2019 with the earliest Ofgem approval at the end of 2020, so any new project would not start before the RIIO-2 period. Given that NIC projects take two to three years, any productionisation would not take place until the latter part of the five-year RIIO-2 period.

This submission does not include a request for funding for future NIC project productionisation. If these do arise, we may need to use Ofgem’s proposed cost trigger mechanism.

2.11.6 Approach

To be determined on a case by case basis.

The capabilities added by the data and analytics platform and the digital engagement platform will be fully used to integrate, extend, or build any new applications needed for any future innovations.

2.11.7 Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	0.6	0.6	1.2	1.2	1.8	**5.4**
Opex	0.4	0.4	0.8	0.8	1.2	**3.6**
Total	**1.0**	**1.0**	**2.0**	**2.0**	**3.0**	**9.0**
Cumulative RTB* increase	0.0	0.0	0.1	0.2	0.3	**0.6**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	5.0
High	10.0

Figure 35 - investment costs

Estimates are at the higher end of the Gartner benchmark due to the accelerating pace of change and the need to be able to continue to realise ongoing consumer benefit from innovation.

2.11.8 Risks

No specific risks have been associated to this investment. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

2.11.9 Options

Option(s)	Pros	Cons
Not invest in this area		• This would prevent us from rolling out learnings from NIA projects, negatively impacting consumer benefit.
Invest in new tools as required.	• Enables the roll out of learnings from NIA projects, where consumer benefit is identified.	

2.12. 460 Restoration

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

2.12.1 Overview

This investment covers changes to systems and communication methods on the back of the findings from the Distributed ReStart innovation project started in RIIO-1.

2.12.2 Current state

Currently we have around 20 black start providers, mostly large traditional generators connected to the transmission network.

As larger traditional generation units close, black start capability is expected to be extended down into the distribution networks. We are considering options to achieve this through the restoration innovation project.

2.12.3 Case for change

The innovation project will change how black start is modelled and controlled, and we will need to update our systems to facilitate this.

There are three main areas of change: communications, control, and visibility. They can impact various systems with different levels.

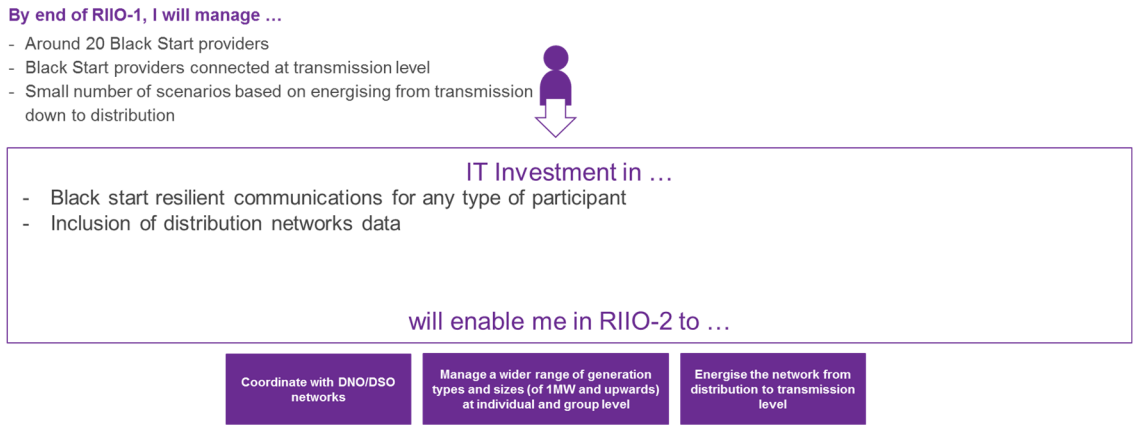

Figure 36 - Use case, investment and outcome expectation

2.12.4 Roadmap

We will start project support work during RIIO-1 and expect to understand full impacts and costs by the end of it.

After the innovation project ends in 2022, we will be implementing the relevant findings throughout RIIO-2.

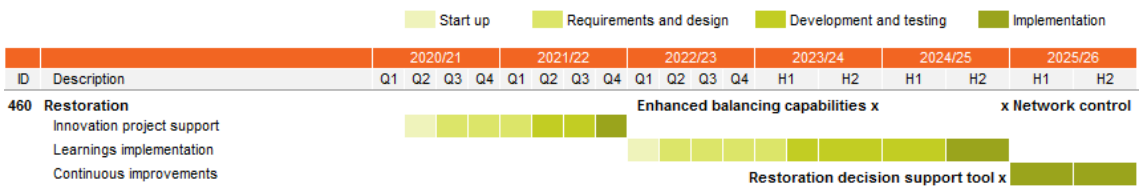

Figure 37 – Delivery plan

2.12.5 Future state

We will support the innovation project for technological solutions and procurement recommendations. From these, we will put in place changes ranging from secure communication links to distributed energy resources (DERs), to creating auctions for restoration services.

2.12.6 Approach

We will use tools from this investment on our CNI estate in our data centres and will use a dedicated control data network (provided by the TOs or DNOs) with guaranteed performance and service levels to communicate with restoration service providers.

Integration between systems will use the capabilities of the data and analytics platform.

2.12.7 Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	0.9	1.8	6.3	6.3	5.4	**20.7**
Opex	0.1	0.2	0.7	0.7	0.6	**2.3**
Total	**1.0**	**2.0**	**7.0**	**7.0**	**6.0**	**23.0**
Cumulative RTB* increase	0.0	0.1	0.3	1.1	1.9	**3.4**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	23.0
High	23.0

Figure 38 - investment costs

Although Gartner's range is the same as our proposal, they have excluded possible communications costs during the trial periods which we may incur. However, we still believe our proposal will deliver its benefits with current estimated level of investment.

2.12.8 Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
Cost of providing sufficient resilience in telecommunications for distributed restoration is higher than projected or new tools are required to achieve its benefits.	• The Network Innovation competition (NIC) DER project will provide a working (albeit small scale) proof of concept solution for resilient telecommunications which can be suitably scaled for GB wide use. • Monitor closely project findings and plans.	2	3

2.12.9 Options

Option(s)	Pros	Cons
Not invest in this area		• Puts at risk 2025 ambition to be able to operate a carbon free electricity system. • Prevents introduction of efficiencies in this operational area. • Increases risk of longer restoration periods.
Update tools and integrate with data platform and enhanced balancing capabilities	• Supports 2025 ambition to be able to operate a carbon free electricity system. • Introduces efficiencies in restoration processes. • Introduces resilient solution.	• Introduces DNO coordination complexity in restoration processes.

2.13. 510 Restoration decision support tool

Current stage:

Scoping	Start-up	Requirements and design	Development and testing	Implementation

2.13.1 Overview

This investment will provide a decision support toolset based on real-time data to deliver a dynamic, feasible restoration plan to Government standards.

2.13.2 Current state

Restoration plans are based on methodologies that mean restoring the whole system area by area, connecting them when possible. Given the limited number of providers and their characteristics, we run a small number of scenarios based on energising the transmission network first and then the distribution.

2.13.3 Case for change

Restoration standards are expected to be issued by the end of RIIO-1. The date for the restoration standard being implemented is dependent on the government. Once the standard is confirmed by the government, we will have 12 months to implement it. Our current estimates are for a standard to be confirmed in October 2020, meaning the ESO would have until October 2021 to implement it. This, allied to the increase in technologies able to provide black start services, means the number of restoration scenarios and options will grow exponentially, making our current methods of creating restoration plans inefficient.

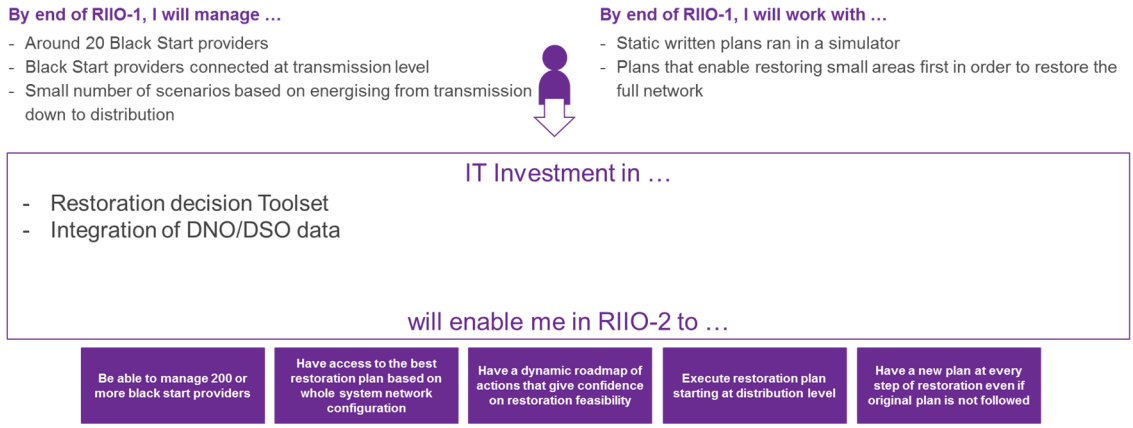

Figure 39 - Use case, investment and outcome expectation

2.13.4 Roadmap

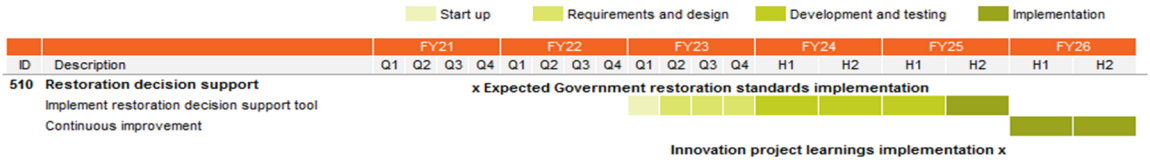

Figure 40 – Delivery plan

2.13.5 Future state

We will implement a tool that runs live with the latest network configuration, providing a dynamic decision tree for the best route to restoration. It will change its output every time the network configuration changes and update live in a restoration situation if the initial recommendation is overruled.

It will be flexible to accommodate learnings from restoration innovation project and meet Government restoration standards, including user defined scenarios for multiple restoration strategies.

2.13.6 Approach

We will ensure this tool is scalable for restoration innovation project learnings using the modelling and analytical tools provided by the data and analytics platform.

2.13.7 Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	0.0	0.5	1.4	1.8	0.9	**4.5**
Opex	0.0	0.1	0.2	0.2	0.1	**0.5**
Total	**0.0**	**0.5**	**1.5**	**2.0**	**1.0**	**5.0**
Cumulative RTB* increase	0.0	0.0	0.1	0.2	0.4	**0.7**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	2.0
High	5.0

Figure 41 - investment costs

Our initial proposal was a higher value than the range given by Gartner. Based on Gartner's feedback, we aligned our proposal to their higher range value. We believe this level of investment will be required given the scale of innovative industry change in this area, which may require bespoke tool components.

2.13.8 Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
Difficult to predict how modelling tools will need to evolve in future due to changing needs and increased understanding of issues.	• Ensure regular review of requirements throughout RIIO-2 period. • Deploy proof of concept tools as early as possible to gain understanding of modelling needs. • Employ agile delivery principles and flexible, modular applications.	3	1
Requirements from restoration innovation project and Government standards are of higher complexity than anticipated.	• Monitor closely innovation project findings and plans from restoration innovation project. • Prioritise delivery plan based on compliance regulations and consumer value.	2	2

2.13.9 Options

Option(s)	Pros	Cons
Not invest in this area		• Creates operational risk, staff overheads and technical debt as it addresses restoration problems with inefficient processes and workarounds. • Puts at risk 2025 ambition to be able to operate a carbon free electricity system. • Prevents introduction of efficiencies from innovation project.
Invest in legacy tools		• Creates operational risk, staff overheads and technical debt as it addresses restoration problems with inefficient solutions and processes. • Puts at risk 2025 ambition to be able to operate a carbon free electricity system at risk. • Prevents introduction of efficiencies from innovation project.
Update tools and integrate with data platform and network control	• Ensures efficient compliance with new restoration standards. • Supports 2025 ambition to be able to operate a carbon free electricity system. • Introduces efficiencies in restoration processes. • Allows introduction of efficiencies from innovation project.	

3. Theme 2 investment lines

3.1. 270 EU regulation

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

3.1.1 Overview

This investment enables the mandatory European Union (EU) regulatory driven change.

This can affect all ESO activities, but the primary impact is on the operation of the markets, so this is categorised under Theme 2. In RIIO-1 period we have experienced a very high degree of regulatory change, which has accelerated in recent years. Due to the rapidly evolving electricity market, and greater degree of political scrutiny, we anticipate this will continue throughout RIIO-2. Annual investment in compliance with EU regulatory changes is included at similar levels to recent RIIO-1 expenditure.

3.1.2 Current state

EU regulatory changes have wide ranging impact on ESO processes and need implementing over several years. They impact multiple systems, including our critical national infrastructure systems.

EU regulatory change in RIIO-1 has included:

- EU Transparency Regulations (ETR): this introduced new reporting requirements and required the ESO to collect data from across the industry and submit it on a regular basis close to real time. It required changes to multiple systems and the creation of a new system, MODIS
- regulation on wholesale energy market integrity and transparency (REMIT): this created further reporting requirements and added to the complexity of the ETR solution
- the third energy package (European network codes), which has a major impact on ESO operational processes. The changes have included:
  - Capacity Allocation and Congestion Management (CACM) guideline, and Common Grid Model (CGM).
  - A new EU market for replacement reserves (Project TERRE). This interacts with our entire end to end GB balancing market processes and has led to major changes to 14 systems, including our CNI balancing systems.
  - General compliance requirements arising from the Electricity Balancing Guideline (EBGL), which define rules that our local GB specific markets and services must follow.

3.1.3 Case for change

The ESO must comply with EU regulations. We assume the UK will remain aligned to the EU Internal Energy Market (IEM) post-Brexit and will remain subject to current and future EU regulations.

3.1.4 Roadmap

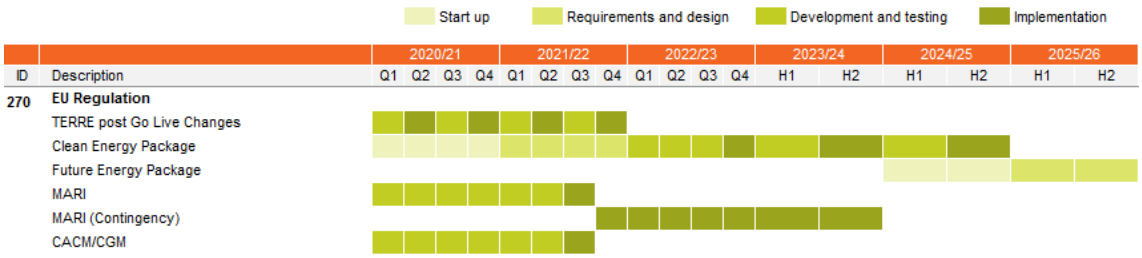

Figure 42 – Delivery plan

3.1.5 Future State

Major regulatory initiatives have a wide-ranging impact on our processes and our IT systems. We usually need to make changes to multiple systems across the whole lifecycle, including our CNI systems.

EU regulatory change expected in the RIIO-2 period includes:

- completion of the third energy package:
  - completion of CACM/CGM: Due to the implementation of the central EU platforms, we now believe some completion activities will be needed in 2021
  - modifications to Project TERRE: after any major regulatory change, there are usually further changes as the impact becomes more apparent. We have allowed for a limited level of change in our submission
  - completion of MARI (implementation of 'manual frequency restoration reserves (mFRR))': This is expected to be of greater size and complexity than Project TERRE. Due to learnings from Project TERRE and expected benefits from the enhanced balancing capability and the data and analytics platform, we expect to deliver this at lower cost than Project TERRE.
- phased implementation of the EU clean energy (4^{th}) package. This includes 'regionalisation' and 'harmonisation' which will have a significant impact on our operations. We anticipate there will be a strong focus on regional coordination of security and outage planning. The introduction of more active regional operation centres will require increased data exchange, information quality, and flexibility, and ESO IT systems will need to be integrated with central platforms. The concept of 'regional balancing reserves' will also have significant IT impact. The scope of this is expected to become clearer towards the end of 2019. Again, this is a major regulatory initiative, potentially of a comparable size to project TERRE.

Other potential changes include reconfiguration of capacity calculation regions or bidding zone review. We have not estimated the cost of these in our submission.

Our plan does not include changes to imbalance settlement period or gate closure time. We also assume we will not need to introduce 'automatic frequency restoration reserves (aFRR)' and that these would need to be treated as a reopener if they occur.

This investment does not include the ESO contribution to the central EU platforms (e.g. the libra platform which is used to coordinate TERRE). These are covered from the business budget.

3.1.6 Approach

There are no specific systems, processes, technologies, or practices associated with this investment. We will use existing capabilities to implement regulatory changes.

3.1.7 Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	9.0	7.2	7.2	7.7	7.7	**38.7**
Opex	1.0	0.8	0.8	0.9	0.9	**4.3**
Total	**10.0**	**8.0**	**8.0**	**8.5**	**8.5**	**43.0**
Cumulative RTB* increase	0.8	1.0	1.2	1.4	1.6	**6.1**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	30.1
High	43.0

Figure 43 - investment costs

Cost estimates reflect recent trends of increased regulatory change, and therefore are at the high end of the Gartner benchmark.

3.1.8 Risks

Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Both the nature and impact of regulatory change are very difficult to predict. Unexpected changes could occur during the price control period, which may lead us to use Ofgem's proposed cost trigger mechanism. This is captured as a portfolio level risk in Appendix C.

3.1.9 Options

Option(s)	Pros	Cons
Not invest in this area		• Does not comply with EU-driven regulatory change. • Does not allow benefits of access to wider EU markets to be passed on to consumers. • Does not allow market participants access to wider EU markets. • Does not deliver the security of supply benefits of increased coordination with other TSOs.
Invest in enhancements	• Facilitates compliance with EU-driven regulatory change. • Facilitates consumer benefits from access to wider EU markets. • Facilitates participant access to wider EU markets. • Facilitates security of supply benefits from increased coordination with other TSOs.	

3.2. 280 GB regulation

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

3.2.1. Overview

This investment allows us to deliver mandatory GB regulatory and market-driven change.

Regulatory-driven change can affect all ESO activities, but the main impact is on market operation, so this is categorised under Theme 2. In the RIIO-1 period we have experienced a very high degree of regulatory change, which has accelerated in recent years.

Due to the rapidly evolving electricity market, and greater degree of political scrutiny, we anticipate that the high-level of regulatory change will continue throughout RIIO-2. We have included annual investment in compliance with EU and GB regulatory changes at similar levels to recent RIIO-1 expenditure.

GB regulatory and market driven changes can arise from multiple sources, for example modifications to the grid code, balancing and settlement code (BSC), or connection and use of system charging (CUSC) code. This investment line does not include CUSC modifications, which are covered separately under IT investment 300 Charging regime and CUSC changes.

3.2.2. Current state

Regulatory changes typically have wide ranging impacts on ESO processes and take several years to implement. They impact multiple systems, including our critical national infrastructure systems.

GB Regulatory and market driven change in RIIO-1 has included:

- Contingency balancing reserves (SBR and DSBR).
- Electricity balancing significant code review (EBSCR).
- Numerous BSC modifications.
- Accelerated wider access.

3.2.3. Case for change

The ESO must comply with GB regulatory and market-driven change, including grid code and balancing and settlement code changes.

3.2.4. Roadmap

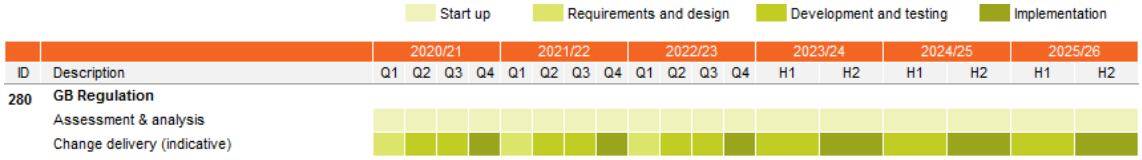

Figure 44 – Delivery plan

3.2.5. Future state

Major regulatory initiatives have a wide-ranging impact on our processes our IT systems. Changes are usually required to multiple systems across the whole lifecycle, including our critical national infrastructure (CNI) systems.

GB market-driven changes generally have a shorter lead time than EU changes, so we cannot predict individual changes at this stage. Examples of potential changes in the

RIIO-2 period are listed below. Their impact is unknown at present, so these have not been estimated explicitly:

- Changes to physical notification (PN) modelling, operational metering, baseline methodology for embedded generation.
- Multiple suppliers for a single meter point administration number (MPAN), e.g. different suppliers for electric vehicle charging vs. onsite generation – a notable change to supplier hub principles.
- Mandatory half hourly settlement for all MPANs – on the face of it no impact on ESO, but there may be knock on effects.

Our plan does not include changes to imbalance settlement period or gate closure time. We also assume we will not have to introduce 'automatic frequency restoration reserves (aFRR)' and that these would need to be treated as a reopener if they occur.

3.2.6. Approach

As with EU regulation, there are no specific systems, processes, technologies, or practices associated with this investment. We will use existing capabilities to implement regulatory changes.

3.2.7. Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	2.7	2.7	2.7	2.7	2.7	**13.5**
Opex	0.3	0.3	0.3	0.3	0.3	**1.5**
Total	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**15.0**
Cumulative RTB* increase	0.0	0.1	0.2	0.2	0.3	**0.8**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	10.5
High	15.0

Figure 45 - investment costs

Cost estimates reflect recent trends of increased regulatory change, and therefore are at the high end of the Gartner benchmark.

3.2.8. Risks

Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Both the nature and impact of regulatory change are very difficult to predict. Unexpected changes could occur during the price control period, which may lead us to use Ofgem's proposed cost trigger mechanism. This is captured as a portfolio level risk in Appendix C.

3.2.9. Options

Option(s)	Pros	Cons
Not invest in this area		• Does not comply with GB market & regulatory-driven change. • Does not allow consumers and market participants to benefit from changes to the electricity markets.

Option(s)	Pros	Cons
Invest in enhancements	• Facilitates compliance with GB market and regulatory-driven change. • Facilitates consumer and customer benefits from changes to the electricity markets.	

3.3. 290 Charging and billing asset health

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

3.3.1. Overview

The Charging and Billing (CAB) system manages Transmission Network Use of System (TNUoS) charges, Balancing Services Use of System (BSUoS) charges and connection charges. It generates invoices for market participants to pay the ESO. TNUoS charges go to the TOs, BSUoS charges to ESO, and connection charges are shared.

This investment completes the re-engineering of the charging and billing system, to manage the increased number of market participants.

3.3.2. Current state

The current CAB system was implemented in 2014 and will be re-engineered by the Revenue 21 project, which starts in RIIO-1 and is expected to complete by 2021/22.

3.3.3. Case for change

The current CAB system will no longer be fit for purpose to support the changing regulatory environment. More flexible systems, and agile project delivery, will be needed to manage the increasing customer base and data requirements. There are also several processes undertaken manually outside the CAB system, which the new ESO revenue systems will capture, supporting compliance requirements (e.g. Sarbanes-Oxley[2]) as well as introducing business efficiencies.

Two Ofgem significant code reviews are currently in progress. These are expected to drive further regulatory change by 2023 and beyond, necessitating a more flexible system. These include the Targeted Charging Review, which is due in 2021, and the Access and Forward-Looking Charges Review due in 2023.

[2] Legislation to protect investors by improving the accuracy and reliability of corporate disclosures.

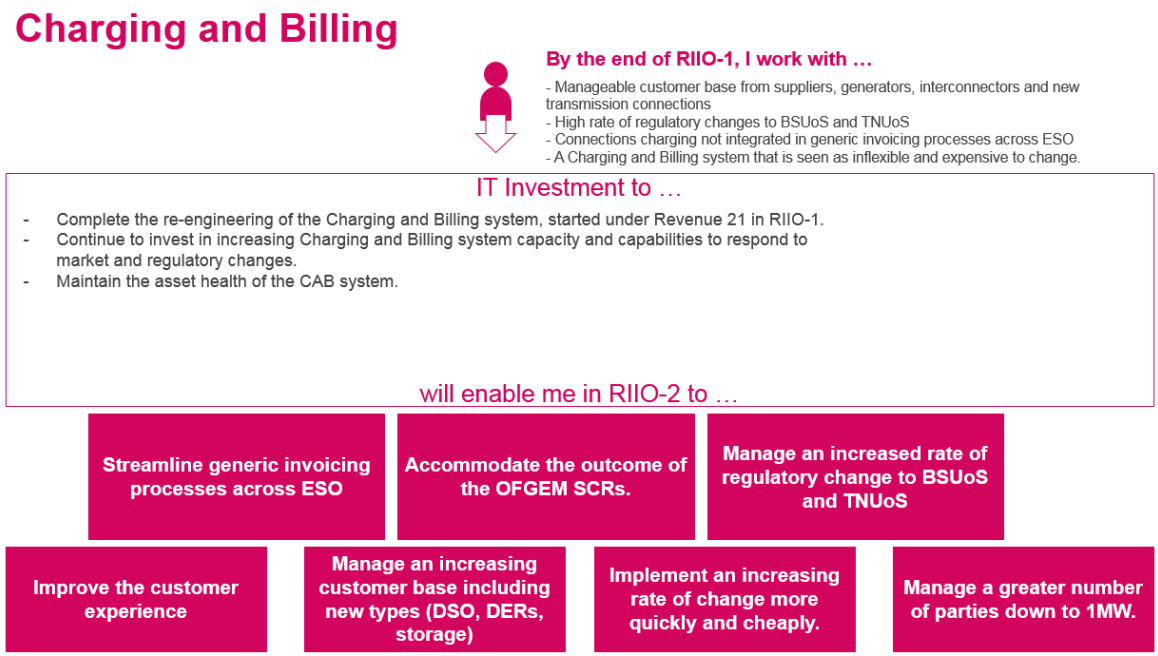

Figure 46 - Use case, investment and outcome expectation

3.3.4. Roadmap

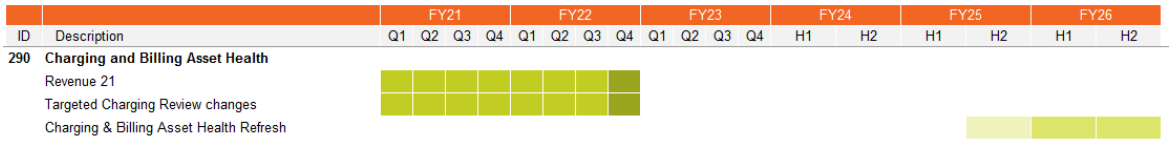

Figure 47 – Delivery plan

3.3.5. Future state

The re-engineering of the charging and billing system is planned to complete in 2021/22. The re-engineered system is planned to be much more flexible than the current system, reducing the lead time and cost for change. We expect that this system will include changes needed for the Targeted Charging Review, and the costs for this are included in this investment.

This system will enable the management of an increasing customer base from suppliers, generators, interconnectors, smaller parties, new technologies (e.g. storage) and new transmission connections. Developments in technology and billing platforms will allow us to use a more flexible and modular architecture, enabling agile and flexible delivery of changes.

This will also streamline charging and invoicing processes across ESO, including connections charging and ad hoc invoicing.

However, there is a risk around the timing of the go live, as the project is currently in the discovery stage. We plan to mitigate this risk by a phased implementation to maximise the early delivery of benefits.

We anticipate that the system will require an asset health refresh shortly after the end of the RIIO-2 period and have included funding for this to begin in the final year of RIIO-2.

3.3.6. Approach

The existing charging and billing system will be re-engineered.

3.3.7. Costs

The cost table below assumes that the re-engineered system will be a customised cloud solution. If this assumption proves to be incorrect, there may be a switch between opex and capex.

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	1.8	0.0	0.0	0.0	1.2	**3.0**
Opex	1.2	0.0	0.0	0.0	0.8	**2.0**
Total	**3.0**	**0.0**	**0.0**	**0.0**	**2.1**	**5.1**
Cumulative RTB* increase	0.4	0.4	0.4	0.4	0.4	**1.9**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	5.0
High	8.3

Figure 48 - investment costs

Costs are at the low end of the Gartner benchmark due to timing. Funding in 2021/22 is to complete the re-engineering started in RIIO-1, and funding in 2025/26 is to start the next refresh which would complete after the RIIO-2 period.

3.3.8. Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
Extended parallel run of the existing and re-engineered charging and billing systems may be required in the transition period, increasing IT running costs.	• Plan to minimise parallel run period.	2	1
Levels of market participation are higher than anticipated, leading to additional investment being required.	• System is being designed to be flexible and extendable.	1	1

3.3.9. Options

Option(s)	Pros	Cons
Not invest in this area		• Puts our ability to manage the charging and billing process at risk. • Leaves tools unsupported and at increasing risk of failure. • Planned improvements in agility and flexibility would not be achieved. • Puts ability to comply with Ofgem SCRs at risk.

Option(s)	Pros	Cons
		• Puts ambition to transform the customer experience at risk. • Increases cost and time to implement future charging and Connection Use of System Code (CUSC) changes. • Prolongs manual processes and increases inefficiencies. • Increases cyber security risk.
Tactical investment in our legacy tools	• Mitigates risk to charging and billing process. • Brings tools into support and reduces risk of failure. • Mitigates cyber security risk.	• Puts ability to comply with Ofgem SCRs at risk. • Puts ambition to transform the customer experience at risk. • Planned improvements in agility and flexibility would not be achieved. • Increases cost and time to implement future charging and CUSC changes. • Prolongs manual processes and increases inefficiencies.
Re-engineer our tools	• Facilitates compliance with Ofgem SCRs. • Facilitates ambition to transform the customer experience. • Implements improvements in agility and flexibility. • Reduces cost and time to implement future charging and CUSC changes. • Removes manual processes and reduces inefficiencies. • Mitigates risk to charging and billing process. • Mitigates cyber security risk. • Brings tools into support and reduces risk of failure.	

3.4. 300 Charging regime and CUSC changes

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

3.4.1. Overview

This investment enables mandatory market-driven change to the Connection and Use of System Code (CUSC) and/or the charging regime.

GB regulatory and market driven changes can arise from multiple sources, for example modifications to the grid code, Balancing and Settlement Code (BSC) or CUSC. This investment line includes charging regime and CUSC modifications only. Other GB regulatory and market driven changes are covered separately under IT investment 280 GB regulation.

3.4.2. Current state

The CUSC is the contractual framework for connection to, and use of, the National Electricity Transmission System (NETS). The ESO is the code administrator and maintains the code and manage changes.

The CUSC sets out the methodology for calculation charges. The ESO uses this for tariff setting and billing for the charges system users must pay.

We have experienced a high degree of change in recent years, and due to the rapidly evolving electricity market, and increased degree of political scrutiny, we believe this will continue. There are also two Ofgem Significant Code Reviews (SCRs) in progress: the Targeted Charging Review (due by 2021) and the Access and Forward Looking Charges Review (due by 2023).

Changes to the charging regime or the CUSC often require changes to the supporting IT systems. The primary system is the charging and billing system, which is insufficiently flexible to accommodate future levels of change. A project is planned to re-engineer this system by 2021/22, as described under IT investment 290 Charging and billing asset health above.

3.4.3. Case for change

Compliance with charging regime and connection and use of system charging (CUSC) market and regulatory-driven change.

3.4.4. Roadmap

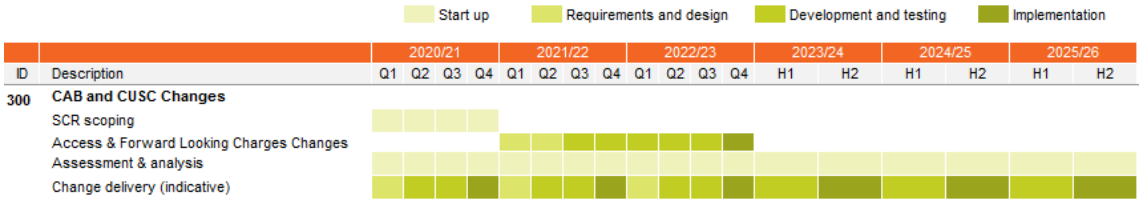

Figure 49 – Delivery plan

3.4.5. Future state

The charging and billing system will be re-engineered in 2021/22 (as described under IT investment 290 Charging and billing asset health above). This system will be much more flexible than the current system, reducing the lead time and cost for change. We anticipate this system will include changes required for the Targeted Charging Review, and the costs are included under IT investment 290 Charging and billing asset health above.

Ofgem is expected to make a decision on the access and forward-looking charges SCR in 2021. It is expected implementation will be required by 2023 to align with RIIO-ED2. The costs of the associated changes are included here.

We anticipate these two SCRs will drive an increasing level of change, which will continue throughout the RIIO-2 period. We will also be exploring options for further digitalisation of our billing processes and giving customers easy access to their data. However, with the implementation of the new system, we expect the overall cost of change to reduce.

3.4.6. Approach

We will build on the new capabilities established by the IT investment 290 Charging and billing asset health. There may be some scope to use the capabilities added by IT investments 220 Data and analytics platform and 250 Digital engagement platform to implement CUSC changes efficiently, for example by using the integration, analytical, and extract, transform and load (ETL) capabilities.

3.4.7. Costs

The cost table below assumes that the re-engineered system will be a customised cloud solution. If this assumption proves to be incorrect, there may be a switch between opex and capex.

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	0.8	0.5	0.5	0.5	0.5	**2.7**
Opex	0.5	0.3	0.3	0.3	0.3	**1.8**
Total	**1.3**	**0.8**	**0.8**	**0.8**	**0.8**	**4.5**
Cumulative RTB* increase	0.0	0.0	0.1	0.1	0.1	**0.2**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	3.1
High	3.6

Figure 50 - investment costs

Estimates exceed Gartner benchmark due to high level of change expected to arise from Ofgem SCRs. Annual expenditure falls in line with benchmark from 2022/23 onwards, once the re-engineered flexible system is implemented.

3.4.8. Risks

Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Both the nature and impact of regulatory change are very difficult to predict. Unexpected changes could occur during the price control period, which may lead us to use Ofgem's proposed cost trigger mechanism. This is captured as a portfolio level risk in Appendix C.

Risks specific to this investment are listed below.

Risk	Mitigation(s)	Likelihood	Impact
Late delivery of the Revenue 21 project benefits would delay introduction of increased flexibility, thus increasing cost and timescale of changes.	• Adopt a modular and agile delivery approach to ensure key benefits are delivered early.	2	1

3.4.9. Options

Option(s)	Pros	Cons
Not invest in this area		• Does not comply with charging regime and CUSC changes. • Does not allow consumers and market participants to benefit from changes to the charging regime and CUSC.
Invest in enhancements	• Facilitates compliance with charging regime and CUSC changes. • Facilitates consumer and customer benefits arising from changes to the charging regime and CUSC.	

3.5. 330 Digitalised code management

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

3.5.1. Overview

Investment to transform the stakeholder experience of the code management process through artificial intelligence enabled navigation, and document and workflow management tools.

3.5.2. Current state

ESO is responsible for administering the Grid Code, SO/TO code (STC) and Connection and Use of System Charging code (CUSC).

These codes, and their supporting documents, consist of thousands of pages of text and are perceived by stakeholders to be difficult to navigate and understand. In the future, the codes process will need to work for hundreds of participants rather than the tens the current process was devised for.

3.5.3. Case for change

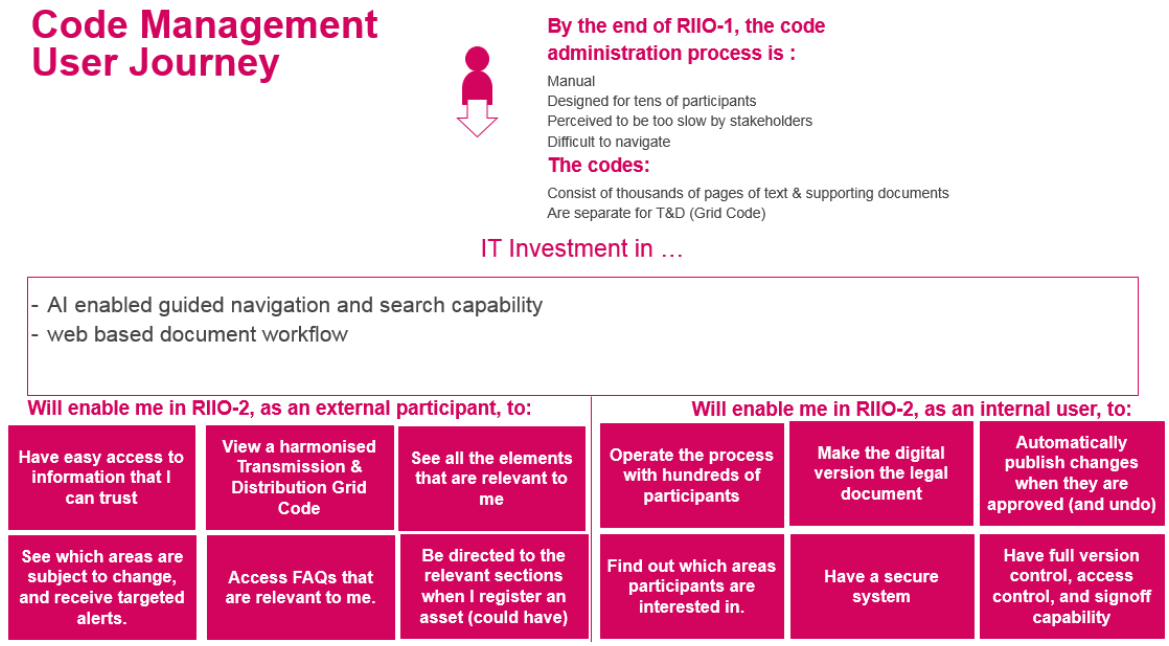

Figure 51 - Use case, investment and outcome expectation

3.5.4. Roadmap

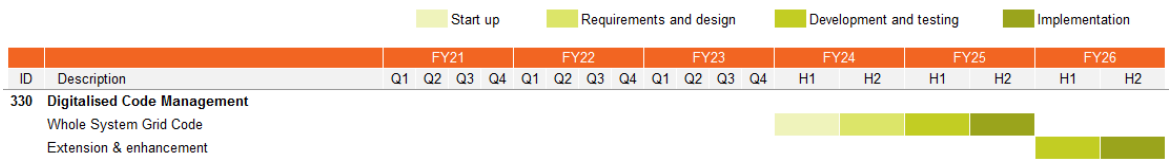

Figure 52 – Delivery plan

3.5.5. Future state

This investment will digitalise and transform the external user experience through artificial intelligence enabled guided navigation and search capability, which will mean stakeholders are guided to the provisions that apply to them, based on their characteristics.

This will be provided for the whole system Grid Code and will be scalable to other codes in an agile phased manner. It will build on our investments in open data and digital engagement. We believe this investment will use a cloud infrastructure to make it easy to extend. The IT architecture build will take place in parallel with the restructuring of the codes.

The code modification process will also be enhanced by the provision of web-based document workflow, to make the change process more efficient and accessible to stakeholders.

This investment will support the digitalisation of the energy system, as recommended by the Energy Data Taskforce (EDTF).

3.5.6. Approach

We will build an enhanced code management hub using the digital engagement platform for customers, giving a consistent user experience and a set of APIs for business-to-business (B2B) integration.

Artificial intelligence will increase the level of automation and self-service. Natural language processing techniques will help participants (and ESO staff) search, interpret and better understand market codes with much less intervention.

3.5.7. Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	0.0	0.0	0.3	0.8	0.5	**1.6**
Opex	0.0	0.0	0.2	0.5	0.3	**1.0**
Total	**0.0**	**0.0**	**0.5**	**1.3**	**0.8**	**2.6**
Cumulative RTB* increase	0.0	0.0	0.0	0.0	0.1	**0.1**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	1.4
High	2.9

Figure 53 - investment costs

Costs are at the high end of the Gartner benchmark due to the complexity of a whole system grid code which covers both transmission and distribution. A transmission only code would fall just below the centre of the range, due to synergies with IT investment 250 Digital engagement platform.

3.5.8. Risks

No specific risks have been associated to this investment. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

3.5.9. Options

Option(s)	Pros	Cons
Not invest in this area		• Does not enable the ambition to create a fully digitalised whole system Grid Code. • Does not enable the digitalisation of the energy system. • Does not provide a more user-friendly, tailored experience for customers. • Does not increase the pace of decision making. • Process would remain manual. • New participants would continue to find it difficult to understand the Grid Code, potentially creating a barrier to entry. • Additional resource would be required to manage the process.
Invest in new standalone tools	• Enables the ambition to create a fully digitalised whole system Grid Code. • Provides a more user-friendly and tailored experience for customers. • Enables quicker decision-making. • Enables automation of processes • New participants would find it easier to understand the Grid Code, and a barrier to entry would be removed. • No need for additional resource to manage the process.	• Inconsistent user experience. • Lack of scalability. • Increased implementation cost due to lack of reuse of enabling technologies.
Invest in new tools and integrate with digital engagement platform	• Enables the ambition to create a fully digitalised whole system Grid Code. • Supports the digitalisation of the energy system, as recommended by the EDTF. • Provides a more user-friendly and tailored experience for customers. • Enables quicker decision-making.	

Option(s)	Pros	Cons
	• Enables automation of processes. • New participants find it easier to understand the Grid Code, and a barrier to entry would be removed. • No need for additional resource to manage the process. • Enables high and consistent customer experience. • Allows for scalability of investment. • Reduced cost from reuse of enabling technologies.	

3.6. 400 Single markets platform

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

3.6.1. Overview

The single markets platform will provide a full end-to-end customer journey allowing market participants to access the data relating to: how to become a provider (obligations, sign up, test, application progression), contract tender (see contracts status and manage contracts), unit management (see what units are registered for, see and change aggregation configurations), dispatch (access instructions), performance monitoring (see how units behaved under instructions), payment. This will include all ancillary service products plus EMR and CfD.

This investment includes a market sandbox to enable faster and more efficient trial of new products through the ability to integrate with the core systems.

3.6.2. Current state

When a new market, or substantial changes to existing markets, are required, we need to change many production systems. These are usually hard to change, translating into costly and time-consuming exercises.

We also have different systems to manage diverse types of participants, i.e. BMUs or non-BMUs.

Smaller distribution-connected providers are currently managed using a variety of legacy systems. We will replace these in the RIIO-1 period with a new ASDP system under the PAS programme. This is designed to be adaptable to new provider types and services.

3.6.3. Case for change

To make our markets work, we must be sure customers can access all the data they need in a convenient way. Given the expected overlaps and interactions between products at transmission and distribution level, having one place to view and manage all market related data is crucial.

With the removal of barriers to entry, new business models, configurations and technologies have started to develop. These in turn bring opportunities and challenges at operational level. We need to capitalise on the opportunities by trialling new ways of managing system balancing needs whilst ensuring we meet security operational needs. We need to have realistic testing capabilities, where market participants can connect and send test data to, validating individual and industry benefits under development conditions.

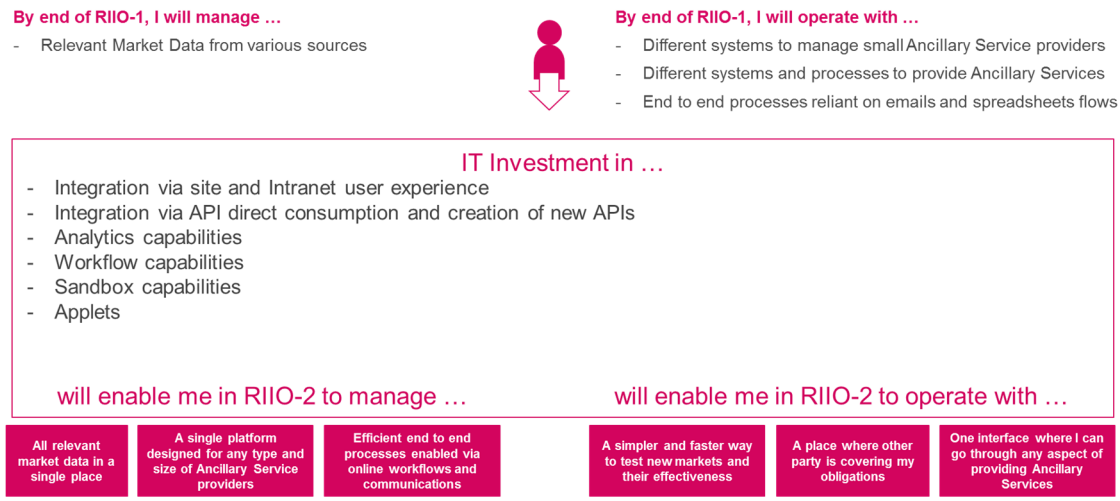

Figure 54 - Use case, investment and outcome expectation

3.6.4. Roadmap

The platform will be based on an asset registry which identifies all characteristics of each unique asset on the transmission or distribution system. This will enable market participants to check their status in the various markets and make appropriate business and investment decisions.

During the first years of RIIO-2, we will create the workflow capabilities for the identified user experience. We will also make the required data available. We will evolve the PAS Customer Relationship Manager (CRM) capabilities in a modular fashion, starting with one product then adding markets in line with stakeholder and operational priorities.

As the single markets platform develops, we will add relevant products and services (existing or new) until all products are accessible, end-to-end.

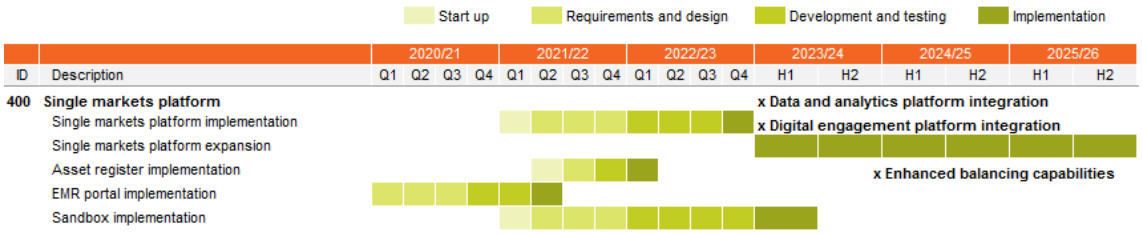

Figure 55 – Delivery plan

3.6.5. Future state

The single markets platform will be a one stop shop for participation in our markets, integrating with the data and analytics platform, providing access to both historical and forecast data and supporting investment cases and decision-making. It will use our enhanced balancing capabilities, including ancillary services dispatch functionalities, and settlement systems. It will also receive and utilise data from DSOs markets when live, allowing clarity on which assets are running in which markets. This will provide a seamless user experience across all markets. Participants will be able to manage their portfolio and have a comprehensive end-to-end view of the whole participation process.

Having the single markets platform will also mean fewer human errors and increased data security.

The investment in a market sandbox will allow us to test new products and services, reducing the time and cost to deploy them into market whilst ensuring they meet both commercial and operational needs. Effectiveness of this model will also depend on the maturity of our balancing and settlements capabilities, increasing as they become more flexible and capable of coping with the pace of change.

3.6.6. Approach

We will implement the single markets platform progressively using solution components and platforms provided by RIIO-1 and other RIIO-2 investments. It will deliver ESO services to participants from a single location, while greatly increasing the level of automation to meet the much higher demand expected during RIIO-2. From the participants' viewpoint, the single markets platform will provide a higher degree of self-service and B2B access (for automation with their own systems).

We will automate market participant processes to meet the increased volume and types of participants, using Salesforce CRM as the main foundation for participant processes. These processes will give a much higher degree of self-service and B2B API access using the digital engagement platform. Artificial intelligence will increase the level of automation and self-service. We will draw on external partners for these implementations.

The single markets platform will be primarily cloud-based, inherited from the underlying platforms.

Implementation of single markets platform will feature industry consultation up front to get the presentation of services right and industry proving/pre-live trials to ensure smooth transitions to live. It is expected that much of the development and integration will be outsourced to our integration partners.

3.6.7. Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	3.1	3.1	2.2	1.2	1.3	**11.0**
Opex	2.1	2.1	1.5	0.8	0.9	**7.3**
Total	**5.2**	**5.2**	**3.6**	**2.1**	**2.2**	**18.3**
Cumulative RTB* increase	0.0	0.6	1.1	1.5	1.8	**5.0**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	14.0
High	20.0

Figure 56 - investment costs

This investment falls close to Gartner's high range given the high level of change expected in all markets included under this platform.

3.6.8. Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
That there are many industry initiatives seeking to develop portals simultaneously and that this is an inefficient and uncoordinated approach (e.g. EDTF, BEIS code governance reform review, BEIS/Ofgem work on smart systems and flexibility)	• Continue to actively participate with many of these activities and continue to coordinate with all relevant parties, including providing feedback to TOs' business plans.	2	1

Risk	Mitigation(s)	Likelihood	Impact
Requirements from market participants are unclear or conflicting.	• Engage market participants regularly via the design authority and show and tells.	2	1

3.6.9. Options

Option(s)	Pros	Cons
Not invest in this area		• No new markets or products will be created. • Does not enable easy and economic data sharing with our customers. • Creates staff overhead and technical debt as it addresses market procurement problems with inefficient processes and workarounds. • Requires higher level of investment in other areas to make up for market procurement inefficiencies. • Puts 2025 ambition to be able to operate a carbon free electricity system at risk. • Does not enable transparency of our actions. • Does not react to or meet new customer data needs in a timely way. • Increases operational risk. • Maintains low costumer experience. • Increases cyber security risk.
Invest in legacy tools		• Does not support easy and economic data sharing with our customers. • Creates staff overheads and technical debt as it addresses engagement problems with inefficient solutions and processes. • Duplicates investment in other areas to make up for lack of market procurement standard solutions.

Option(s)	Pros	Cons
		• Puts at risk 2025 ambition to be able to operate a carbon free electricity system. • Does not enable transparency. • Does not react to or meet new customer data needs in a timely way. • Maintains low costumer experience. • Increases cyber security risk.
Update tools and integrate with digital engagement platform, data platform, network control and enhanced balancing capabilities	• Enables 2025 ambition to be able to operate a carbon free electricity system. • Enables transparency. • Enables easy and economic data sharing with our customers. • Allows for scalability of investment. • Introduces market procurement standards. • Enables high and consistent costumer experience. • Enables introduction of efficient processes. • Enables quicker response to market needs.	

3.7. 410 Ancillary service settlements refresh

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

3.7.1. Overview

Replacement of, and ongoing investment in, the ancillary services settlement system, to manage the increased number of market participants and increasing rates of change.

3.7.2. Current state

The ancillary services settlement system calculates payments for services provided to the ESO. Whilst the system can manage these in current enviroment, it does not have sufficient flexibility to cope with the expected increase in the number of new services and participants. The settlements process also needs significant manual intervention.

A project to replace the system is currently in the requirements stage and is expected to complete early in the RIIO-2 period.

3.7.3. Case for change

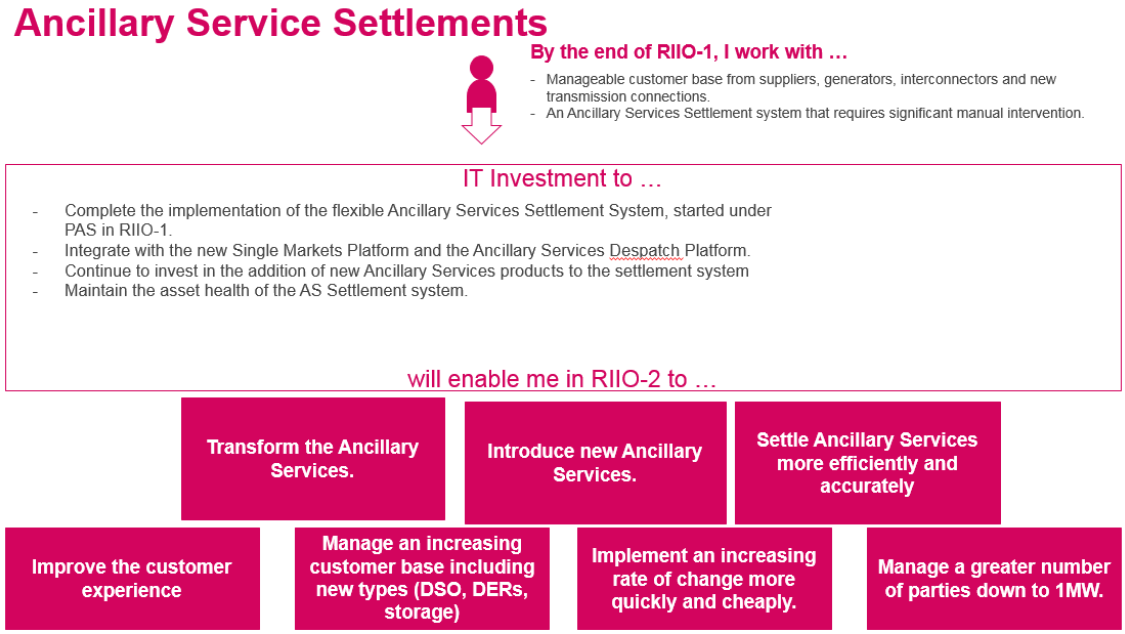

Figure 57 - Use case, investment and outcome expectation

3.7.4. Roadmap

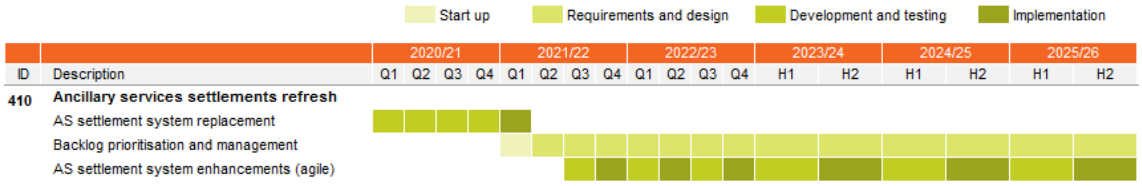

Figure 58 – Delivery plan

3.7.5. Future state

This system is being replaced by the platform for ancillary services (PAS) project, which is under way in RIIO-1 and is expected to complete in 2021. The new system will enable settlement of ancillary services to be carried out more efficiently and accurately, and will more easily manage the increasing number of market participants (down to 1 MW) and

changes in ancillary services. It will also include automated online account management. Ongoing investment will enable addition of new ancillary services as required and integration with the single markets platform.

This investment, along with the digital engagement investment in open data, will enable access to historical, current and forecast billing information, which is a key requirement as part of the customer journey.

3.7.6. Approach

We will use the tools and capabilities of the digital experience, data and analytics platform to further enhance, automate, and integrate the new settlement system.

We will integrate it into our customer portal to give a seamless user experience for customers cf. IT investment 250 Digital engagement platform above.

We will provide customers with API and dataset access to our settlement services and data to allow them to integrate (automate) our settlement processes into their own business processes.

We will integrate ancillary services dispatch and other operational systems into the settlements solution using our SOA and the data platform.

3.7.7. Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	2.1	0.2	0.2	0.2	0.2	**2.8**
Opex	1.4	0.1	0.1	0.1	0.1	**1.9**
Total	**3.5**	**0.3**	**0.3**	**0.3**	**0.3**	**4.7**
Cumulative RTB* increase	0.1	0.2	0.2	0.2	0.3	**1.1**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	1.6
High	4.1

Figure 59 - investment costs

Our estimate is higher than Gartner benchmark, as we plan to implement a new system in 2021/22, then continually enhance it to add new services in response to evolving market requirements throughout the RIIO-2 period.

3.7.8. Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
Levels of market participation are higher than anticipated, leading to additional investment being required.	• System is being designed to be flexible and extendable.	1	1
Extended parallel run of the old and new Ancillary Services Settlements systems may be required in the transition period, increasing IT running costs.	• Plan to minimise parallel run period.	2	1

3.7.9. Options

Option(s)	Pros	Cons
Not invest in this area		• Puts our ability to manage the settlements process at risk. • Leaves tools unsupported and at increasing risk of failure. • Planned improvements in agility and flexibility would not be achieved, making it more difficult to introduce new ancillary services and manage increasing numbers of participants. • Puts ambition to transform the customer experience at risk. • Prolongs manual processes and increases inefficiencies. • Increases cyber security risk.
Carry on investing in our legacy tools	• Mitigates risk to settlements process. • Brings tools into support and reduces risk of failure. • Mitigates cyber security risk.	• Planned improvements in agility and flexibility would not be achieved, making it more difficult to introduce new ancillary services and manage increasing numbers of participants. • Puts ambition to transform the customer experience at risk. • Prolongs manual processes and increases inefficiencies.
Update our tools	• Facilitates ambition to transform the customer experience. • Improves agility and flexibility. • Reduces cost and time to implement future changes. • Removes manual processes and reduces inefficiencies. • Mitigates risk to settlements process. • Brings tools into support and reduces risk of failure. • Mitigates cyber security risk.	

3.8. 420 Auction capability

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

3.8.1. Overview

We will invest in common auction capability and apply economies of scale for more efficient action-based procurement activities. This capability will be expandable to all types of auctions and allow for appropriate running frequency: EMR, CfD, reserve, response, reserve and response, reactive power.

Where possible, efficiency benefits from auctions will also be implemented in tender-based service procurements.

3.8.2. Current state

Medium term procurement of ancillary services is currently carried out via a tender process, on a monthly to triannual basis. This is mainly underpinned by user written spreadsheets. FFR trial innovation project is currently under way to explore the feasibility of using an auction platform to procure balancing services closer to real time (e.g. weekly or day ahead). One of this project's learnings is that it takes a long time to implement given the peripheral legacy systems affected.

EMR and CfD function, which was implemented in RIIO-1, operates in isolation in the IT architecture. Its development and support is now offshore to gain better value for money. All development is done in an agile manner to best enable all the changes deemed necessary by Ofgem and BEIS. The tool is hard to change, and some development is risky, with assumptions that can only be validated closer to go live date given the time it takes to implement the full change. In other cases, bigger changes raised closer to auction running are deemed impossible to implement and get postponed to later auctions.

3.8.3. Case for change

Current quarterly to annual tender, and even monthly, processes are not flexible enough for our customers, and a barrier to market entry. Intermittent generation finds it difficult to predict output in the long term and is excluded from many services.

We anticipate the desire for closer to real-time procurement of ancillary services will continue, as it unlocks further market participation and competition, so we plan to develop a common auction capability. This will build on the learnings of the RIIO-1 auction innovation project, extending the capability to all other services being auctioned over the RIIO-2 period.

This investment also allows us to address customer feedback that the ESO EMR systems are difficult to change. We will implement a new solution built around customer requirements and that is agile, flexible and future proof.

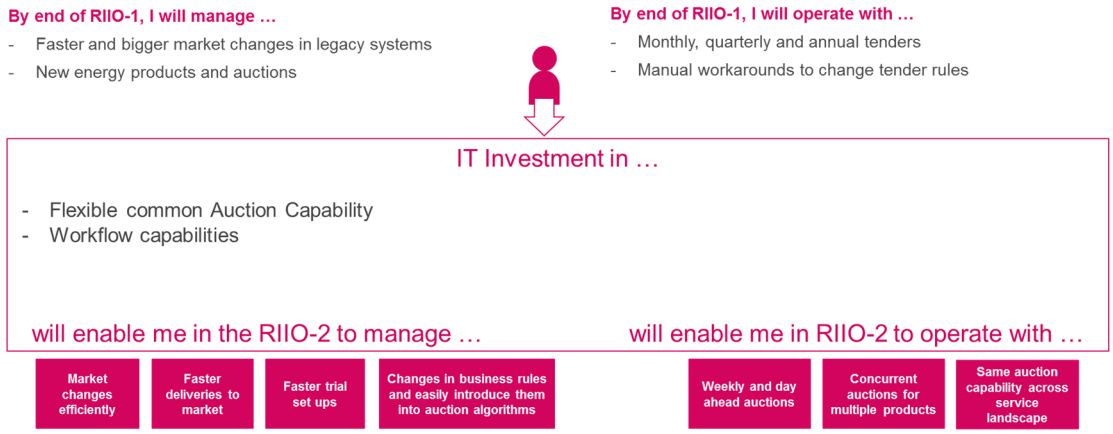

Figure 60 - Use case, investment and outcome expectation

3.8.4. Roadmap

We will use the current innovation project to test if capabilities can be expanded to all other relevant services, exploring in RIIO-1 which options are viable for implementation of the wider auction capability.

Our assumption is that we will start RIIO-2 with a view on an auction capability that is flexible and efficient to scale and expand to all possible new and existing auctioned services. We will implement this tool in the first year, allowing the various auctions' algorithms to be developed in parallel in subsequent years.

In the later years of RIIO-2, we will implement capabilities that account for impact from DSOs, such as constraints or market players already participating in DSO markets.

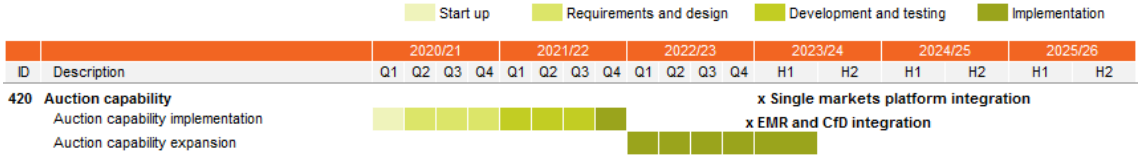

Figure 61 – Delivery plan

3.8.5. Future state

Our auction capability will be scalable to new services and products, with multiple algorithms for auctions at different frequencies, spanning from yearly to day ahead. This will include algorithms for co-optimised response and reserve day-ahead auction which also considers impact on DSOs.

It will use the asset register in our IT investment 220 Data and analytics platform to ensure market participants can provide declared volumes. This will require standardisation or mapping of similar concepts across markets.

The auction capability will be integrated with IT investment 180 Enhanced balancing capability and the IT investment 410 Ancillary service settlement system for faster trials or new balancing services auctions. The full cost and implementation reduction benefits will not be realised until all these capabilities are integrated.

We anticipate towards the end of RIIO-2 between six to eight services, each running one auction with variable frequencies, requiring the same amount of parallel auction algorithms. This capability is expected to be bought from a third party as it is not deemed CNI.

3.8.6. Approach

We will select a provider of energy markets for the base auction capability.

The existing footprint with UK energy markets and participants will be an important factor in the selection process and we will consider integration (UI and B2B) between the participant community and the provider.

The auction markets will be integrated into the single markets platform to provide a common participant experience across common processes such as market registration, settlement and billing.

The auction markets will be hosted and provided as a SaaS solution by the provider.

Implementation will be owned and managed by the ESO. The ESO will consult with the Industry to roll out of services right. Industry proving/pre-live trials will ensure smooth transitions to go live. We expect much of the development and integration will be outsourced to our integration partners.

3.8.7. Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	0.0	0.0	0.0	0.0	0.0	**0.0**
Opex	4.0	2.0	2.0	0.0	0.0	**8.0**
Total	**4.0**	**2.0**	**2.0**	**0.0**	**0.0**	**8.0**
Cumulative RTB* increase	0.1	0.5	0.8	1.0	1.0	**3.4**

*RTB - run-the-business on-going opex

Gartner benchmark range

Low	4.2
High	8.3

Figure 62 - investment costs

This investment falls close to Gartner's high range given the high level of change expected in services included under this capability.

3.8.8. Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
A single auction supplier may not be able to create and support all future auctions, leading to the need to contract with multiple auction suppliers.	• Ensure chosen supplier can meet all current and future ESO needs as part of the tender process.	2	1

3.8.9. Options

Option(s)	Pros	Cons
Not invest in this area		• No new auctions or tenders will be created. • Increases operational risk. • Puts at risk 2025 ambition to be able to operate a carbon free electricity system. • Puts single markets platform costumer value at risk. • Maintains low costumer experience. • Increases cyber security risk. • Leaves tools unsupported and underperforming. • Does not enable transparency.
Individual auction data energy package	• Enables transparency.	• Does not provide single user experience. • Duplicates investment in other areas to make up for lack of auction standard solutions. • Prevents efficiencies through economies of scale. • Puts single markets platform costumer value at risk.
All auctions in a single capability	• Enables single markets platform costumer value. • Supports 2025 ambition to be able to operate a carbon free electricity system. • Enables transparency. • Allows for economies of scale. • Introduces market procurement standards. • Enables high and consistent costumer experience. • Enables introduction of efficient processes.	• Creates dependency on single auction solution.

4. Theme 3 investment lines

4.1. 390 *NOA* enhancements

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

4.1.1. Overview

Our modelling capabilities underpin all our deliverables in Theme 3 and many in Theme 4, enabling us to unlock significant benefits. We need to manage the increasing number of scenarios and modelling complexity driven by the growing interaction between different network needs. The better we understand likely needs, the better we can identify where and when to invest most efficiently.

These investments are necessary to support delivery of all *the Network Options Assessment (NOA)* activities described in the Theme 3 chapter.

4.1.2. Current state

During RIIO-1 we have made some significant enhancements, including the introduction of the *NOA* in 2016. Network needs have become more challenging and our analysis is developing to increase our understanding and modelling of voltage and stability. We have also made big steps forward towards a probabilistic analytical approach, which provides a more refined assessment of network needs across the year rather than at a single point.

Our analytical tools focus on thermal needs and some voltage issues. We need to expand this to cover all energy-related network issues. Work is already under way to develop our capabilities, and our current tool is scheduled to be refreshed before the end of RIIO-1.

Proof of concept work is under way to develop probabilistic techniques for thermal issues. By Q4 2021/22 we intend to have developed the modelling further to account for ESO actions to optimise the capability of the network, such as directing and controlling the power flow across the network. We are also investigating a new voltage assessment tool that can examine more scenarios more quickly, alongside new algorithms to allow faster stability assessment for control centre purposes. Better tools to identify and plan for future stability issues are included in our needs.

The innovative techniques currently being explored will need to be implemented in RIIO-2 and we anticipate further benefits as they develop. For example, greater integration between modelling tools will allow us to better understand the interactions between network needs and to optimise decision-making.

4.1.3. Case for change

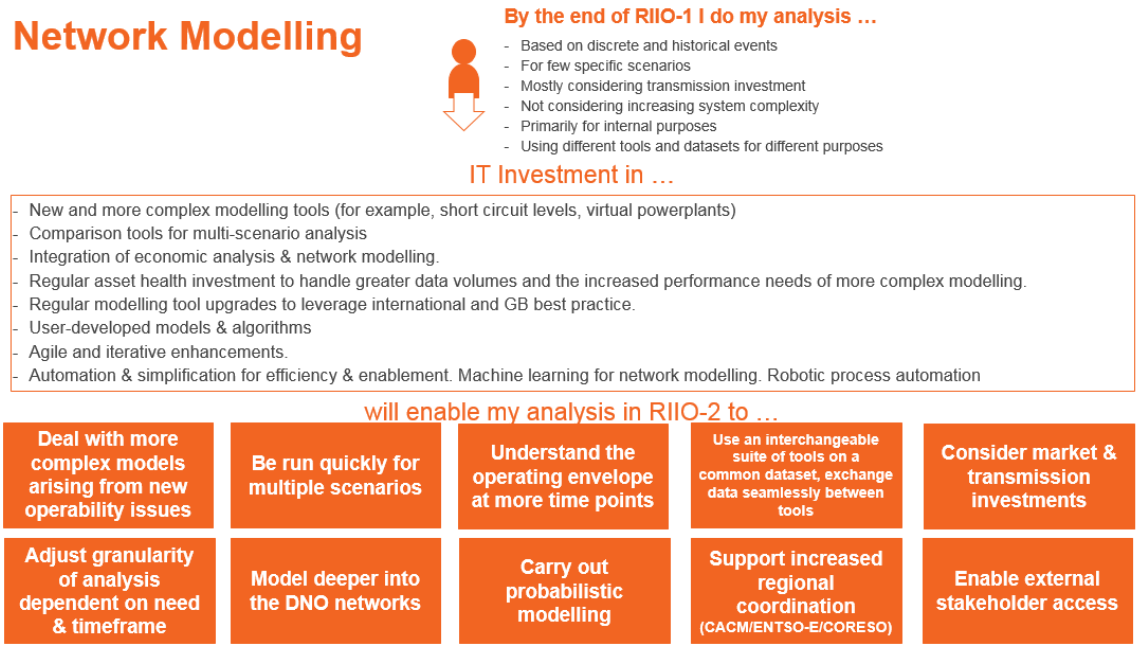

Figure 63 - Use case, investment and outcome expectation

We will integrate our *NOA* modelling and IT investment 360 Offline network modelling tools to provide an interchangeable suite of tools using a common dataset. This user journey covers both areas.

4.1.4. Roadmap

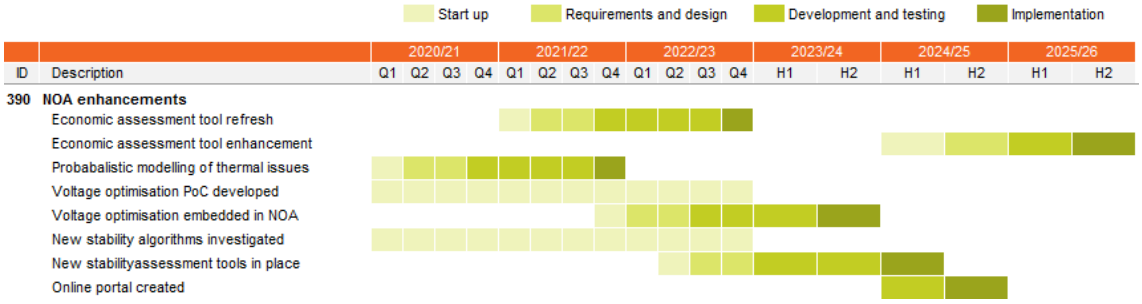

Figure 64 – Delivery plan

4.1.5. Future state

The investment will ensure that the increasing number of scenarios and greater modelling complexity can be managed and to deliver tools which allow more probabilistic-based analysis. The following improvements will be required:

- an appropriate suite of tools to cover all aspects of modelling and improve integration. We will integrate our assessments (e.g. thermal probabilistic, voltage, stability and economic modelling) either in a single platform or through a joined-up analysis process that allows us to 'stack' different network needs to deliver the most economic decision
- integrate our *NOA* modelling tools with IT investment 220 Data and analytics platform. This will deliver an interchangeable suite of tools with a common dataset, and seamless exchange of data between tools, including the transmission analysis tools described in IT investment 360 Offline network modelling. This will allow us to adjust the level of detail in any analysis
- accommodate a significant increase in the volumes of data
- allow simple input and change parameters in the systems.

We plan to implement the following specific tools more fully described in the Theme 3 chapter:

- Economic Assessment
- Probabilistic Modelling
- Voltage Optimisation
- Stability Assessment.

These tools will also support the development of a regime for an Integrated Offshore Grid, which is described in Theme 4.

Asset health investment is also needed to ensure the tools continue to run on supported hardware and that user-developed models and algorithms can be integrated. We estimate the number of network solutions analyses will double in the RIIO-2 period, and investment will be required to allow this.

Subject to the success of our probabilistic modelling and voltage optimisation, from 2024 onwards we will provide an online portal for stakeholders to see a visual representation of network needs and to potentially test high-level solutions. It is expected that this would build on the analytical capabilities of the data and analytics platform and use a similar graphical interface to the connections platform.

4.1.6. Approach

We will follow a best of breed approach to expand our network options and meet the volume and complexity demands of RIIO-2. This will involve a 'reuse before buy, buy before build' principle.

We will continue to extend network modelling and analysis packages where they satisfy strategic requirement, for example Digsilent PowerFactory and Pöyry BID3.

Where existing packages are unable to meet future requirements, we will either go to the market for new network modelling packages or will develop in house tools.

We will build upon investment 220 Data and analytics platform to enable an interchangeable suite of tools to utilise a common dataset.

4.1.7. Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	3.0	3.0	3.2	1.6	1.2	**12.1**
Opex	0.8	0.8	0.8	0.4	0.3	**3.0**
Total	**3.8**	**3.8**	**4.0**	**2.0**	**1.5**	**15.1**
Cumulative RTB* increase	0.0	0.2	0.3	0.5	0.6	**1.6**

*RTB - run-the-business on-going opex

Gartner benchmark range

Low	8.0
High	16.0

Figure 65 - investment costs

We plan to invest strongly in this area, due to the high level of expected benefits. Expenditure is therefore at the high end of the benchmark.

4.1.8. Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
The ESO may need to develop additional *NOA* modelling capabilities to assess individual connection wider works.	• Ensure efficient processes are in place to assess new areas.	3	1
Difficult to predict how modelling tools will need to evolve in future due to changing needs and increased understanding of issues.	• Ensure regular review of requirements throughout RIIO-2 period. • Deploy proof of concept tools as early as possible to gain understanding of modelling needs. • Employ agile delivery principles and flexible, modular applications.	3	1
It may prove difficult to achieve a common dataset for all modelling requirements. If so, costs may increase due to more complex implementation	• Understand data needs early in project life • Have data stewards and a data centric culture supported by data management tools in data and analytics platform.	3	1

4.1.9. Options

Option(s)	Pros	Cons
Not invest in this area		• Unable to continue economic modelling activities beyond 2022/23. • Does not enable the ambition to embed competition and expand the *NOA*. • Does not enable external stakeholder access.
Invest in legacy tools only	• Enables continued economic modelling. • Enables increase in the number of network solution analyses.	• Does not enable the ambition to embed competition and expand the *NOA*. • Does not enable external stakeholder access. • Modelling tools would continue to operate with separate data sources, making dealing with an increasing workload more difficult.
Invest in standalone tools	• Enables continued economic modelling. • Enables increase in the number of network solution analyses.	• Does not enable holistic decision-making. • Does not enable adjustment of the level of analysis.

Option(s)	Pros	Cons
	• Enables the business ambition to embed competition and expand the *NOA*. • Enables external stakeholder access.	• Modelling tools would continue to operate with separate data sources, making dealing with an increasing workload more difficult.
Invest in new tools and integrate with data & analytics platform	• Enables continued economic modelling. • Enables increase in the number of network solution analyses. • Enables the ambition to embed competition and expand the *NOA*. • Enables external stakeholder access. • Enables holistic decision-making. • Enables adjustment of the level of analysis. • Modelling tools would operate with the same data sources, thus mitigating an increasing workload.	

5. Theme 4 investment lines

5.1. 340 RDP implementation and extension

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

5.1.1. Overview

This investment will establish an integrated data exchange and situational awareness capability with all DSOs, enabling coordinated access to Distributed Energy Resources (DER) and management of service conflicts, via the extension of the Regional Development Programmes (RDPs).

5.1.2. Current state

At present, the ESO has limited visibility of conditions in the distribution networks and of connected parties. Real-time links are in place with a small number of DNOs. Coordination of actions with the distribution networks is handled manually, creating the risk of conflicts.

In RIIO-1 we enhanced our activities through the regional development programmes which are looking across the whole electricity system landscape to identify opportunity for additional network capacity, reduced constraints, and to open up new revenue streams for market participants.

These will be developed on a needs basis and we have committed during 2019/21 to work with other network organisations to proactively identify their needs.

5.1.3. Case for change

As the number of service providers embedded in the distribution networks increases, this can create more issues at the transmission/distribution interface. This in turn can delay the connection of DER to the network. The proposed approach allows RDPs to be developed in response to specific network issues as they arise.

It will also become increasingly difficult to coordinate actions manually. Greater interaction with TOs and DSOs is expected, necessitating greater sharing of information to enable operation across boundaries and understanding the impacts of actions on other parties.

Investing in this area also aligns with the Energy Data Taskforce (EDTF) key finding in operational optimisation, enabling operational data to support system optimisation and facilitating multiple players to participate at all levels across the system.

5.1.4. Roadmap

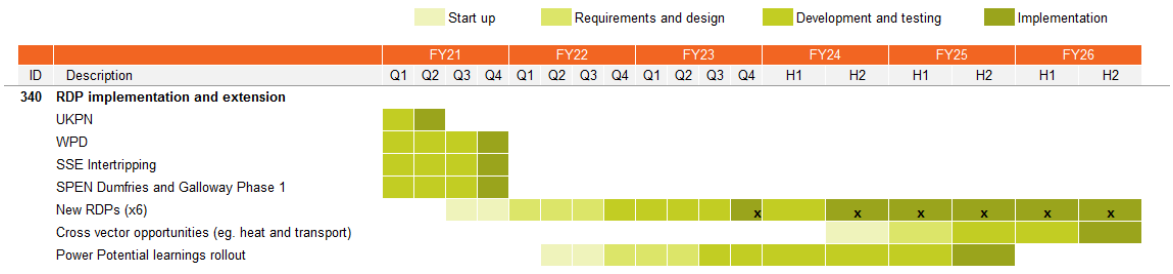

Figure 66 – Delivery plan

5.1.5. Future state

This investment will provide ESO with situational awareness of the DSO networks, and connected parties, through an integrated real-time data exchange and situational

awareness capability with DSOs. We will establish real-time data links with all DSOs, and data volumes are expected to increase significantly. These will be integrated with the DSO ANM systems where appropriate.

This will enable the resolution of issues at the transmission/distribution interface, and allow new DER to be connected more quickly and efficiently.

It will also enable us to manage more service providers, have greater access to flexibility markets, coordinate access to DER and manage service conflicts with DSOs.

This will happen through the extension of RDPs to other areas, or the introduction of new RDPs as required to solve network issues, and we will work with DSOs to progress these. This investment will fund a total of six RDPs across the RIIO-2 period. Our current RDP delivery costs are around £4 million in RIIO-1. We believe we can reduce this to around £2.4 million per RDP through a standardised approach.

This investment will also include the roll out to other areas of learnings from the power potential innovation project.

Opportunities and needs arising from the electrification of heat and transport have been included as additional investment towards the end of the RIIO-2 period.

5.1.6. Approach

We will complement and extend the approach for IT investment 110 Network control above to support the RDPs.

We expect to use the tools and capabilities of the digital experience, data and analytics platform to capture, store, analyse, and present data from multiple new sources and forms in real time.

This will provide for the widest range of application and data integration to exchange situational data with participants and DSOs.

The core capabilities for real-time DSO interaction will be very high availability and high resiliency and will be used on our CNI estate in our data centres. However, some supporting capabilities may be deployed in a cloud environment.

5.1.7. Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	2.9	3.2	3.2	5.4	9.9	**24.5**
Opex	0.3	0.4	0.4	0.6	1.1	**2.7**
Total	**3.3**	**3.5**	**3.5**	**6.0**	**11.0**	**27.3**
Cumulative RTB* increase	0.3	0.6	1.0	1.4	2.1	**5.4**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	27.3
High	27.3

Figure 67 - investment costs

Within ESO, there are systems or activities that are niche to our industry and, in some cases, to our organisation and market, such as our Regional Development Program activities. These cannot easily be benchmarked by Gartner. In this instance, Gartner passes through our estimates, as they are the most accurate values available.

5.1.8. Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
Level of investment required in RDPs will depend on the nature of the ESO / DSO relationship, which is still evolving. Our working assumption is that the relationship will align least regrets with the coordinated and collaborative approach described by the future worlds 'world B'. We have assumed that we will deliver six RDPs in the RIIO-2 period. Costs could vary up or down if these assumptions prove to be incorrect.	• Engage closely with the business and monitor development of the whole system approach. • Ensure the benefits for end consumers of the RDP approach are understood. • Put into action the RDP identification process being developed as part of the 2019-21 ESO *Forward Plan*	3	1
Risk of misalignment with DSOs regarding objectives, timescales and ability to fund investments.	• Engage closely with DSOs and progressively develop ways of working.	2	1

5.1.9. Options

Option(s)	Pros	Cons
Not invest in this area		• Prevent the benefits of the RDP approach being realised. • Does not support operational optimisation. • Does not support resolution of network issues across the transmission-distribution interface. • Delays the transition to whole system operation. • Delays the connection of new DER. • Puts at risk 2025 ambition to be able to operate a carbon free electricity system. • Increased operational risk from limited visibility of embedded generation. • Increased risk of service conflicts between ESO and DSOs. • Unable to benefit from learnings of the Power Potential project. • Unable to address emerging cross-vector issues.
New enhanced capability	• Realises the benefits of the RDP approach.	

Option(s)	Pros	Cons
	• Enables operational optimisation, in line with the key findings of the EDTF. • Supports resolution of network issues across the T-D interface. • Enables the transition to whole system operation. • Enables to the connection of new DER. • Facilitates the 2025 ambition to be able to operate a carbon free electricity system. • Reduces operational risk from limited visibility of embedded generation. • Reduces risk of service conflicts between ESO and DSOs. • Enables the benefits of the learnings from the Power Potential project to be realised. • Helps address emerging cross-vector issues.	

5.2. 350 Planning and outage data exchange

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

5.2.1. Overview

Enhancement of outage planning and data exchange systems to enable a whole system approach to access networks, manage significantly increased data volumes, and provide interactive stakeholder engagement.

5.2.2. Current state

Exchange of outage planning data is currently handled by the Transmission Outage and Generator Availability (TOGA) system. Stakeholders have told us that manual processes are inconsistent, that communications are poor, and that the user experience could be enhanced. This feedback informs the scope of the TOGA replacement project, due to deliver in April 2020. We have developed specifications and begun agile delivery.

Submission of transmission and distribution system network data and models uses a system called External Data Exchange (EDE). This is designed for annual one-way submission of data to the ESO and will not be fit for purpose for the anticipated increase in data volumes and frequency of updates needed future coordination with DNOs. EDE will be due for replacement early in the RIIO-2 period and will need enhancements to cover other forms of customer data submission, implement process improvements and handle increasing data volumes.

At present, a lot of data validation is carried out manually. In RIIO-1 we have increased efficiency through automation of selected processes, and we will continue to build on this is RIIO-2.

5.2.3. Case for change

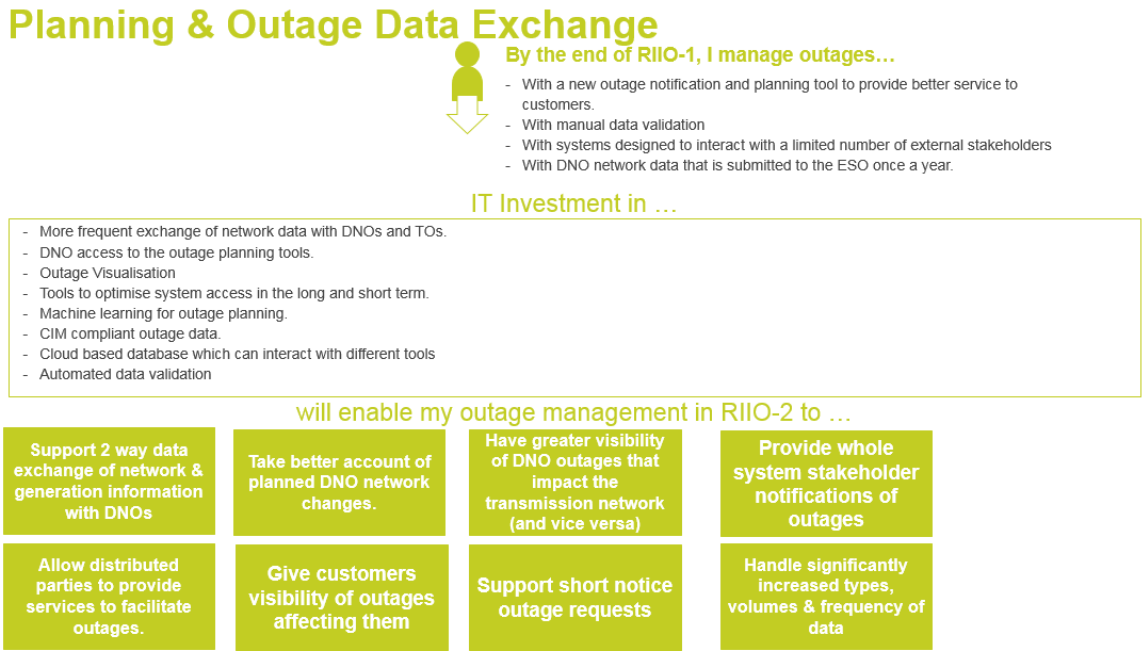

Figure 68 - Use case, investment and outcome expectation

5.2.4. Roadmap

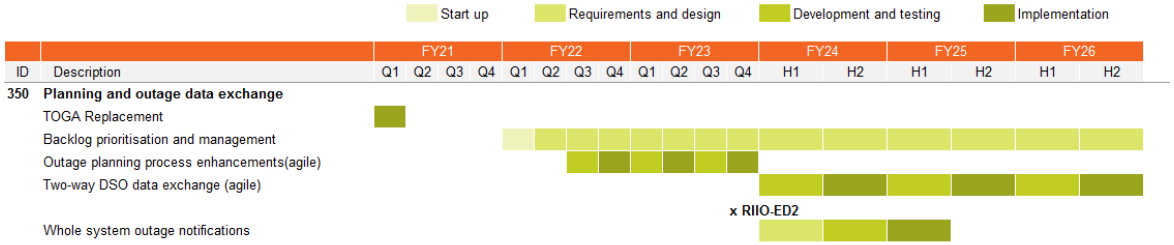

Figure 69 – Delivery plan

5.2.5. Future state

We expect a significant increase in the frequency, complexity and volumes of data exchanged between the ESO, DSOs and TOs as the need for whole electricity system coordination increases, and competition emerges in transmission. We will move from simply collecting winter peak data to exchanging data more frequently. We will need greater volumes of information about distributed energy resources, for example their capacity, location and type.

The way network data, regional models and outage planning data is exchanged will need to be transformed. The legacy methods of file transfer and faxing are not fit for the future and will be replaced with new flexible digital channels. Access to systems will be extended to a wider range of stakeholders with differing business models and needs.

To manage the greatly increased future workload, we will continue to build on the replacement for the TOGA system and further improve the outage planning process. Proposed enhancements in the RIIO-2 period include:

- outage visualisation capability
- tools to optimise system access in the long and short term
- machine learning for outage planning
- implementation of common information model (CIM) compliant outage data.

We need to transform how we keep stakeholders informed of outages. We will introduce better digital communication with customers, stakeholders and the market, for example by using mobile apps, alerts, social media feeds and new digital enabler technologies. We will integrate with IT investment 250 Digital engagement platform to provide a seamless experience to customers and stakeholders.

The EDE system will be replaced with a system that can handle much greater volumes of data and more frequent updates. We will also enable two-way data exchange with DSOs, including full network models for their areas, and likely system flows. We will integrate our data exchange capabilities with IT investment 220 Data and analytics platform. This will provide a seamless exchange of data between tools.

Investing in this area aligns with the EDTF key finding around infrastructure and asset visibility, identifying system assets and infrastructure, where they are located and their capabilities, to inform system planning and management.

5.2.6. Approach

Building on the replacement TOGA system, we will develop new interchange services for other industry parties. These will support two-way exchange of data in formats suitable for a range of data flows.

These services will utilise the capabilities provided by the IT investment 250 Digital engagement platform. They will be developed to meet the needs of the RIIO-2 programme and provide for the widest range of application and data integration styles. These will be used to exchange situational data with participants, DSOs, the TOs and Ofgem.

We will also build upon IT Investment 220 Data and analytics platform to enable an interchangeable suite of tools to utilise a common dataset. Artificial intelligence will be used to automate parts of the outage planning process, where appropriate.

As elsewhere, we will outsource much of the development and integration work to our partners, while building our in-house capabilities in data science, big data and artificial intelligence.

5.2.7. Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	0.4	0.4	1.2	1.4	1.4	**4.8**
Opex	0.1	0.1	0.3	0.4	0.4	**1.2**
Total	**0.5**	**0.5**	**1.5**	**1.8**	**1.8**	**6.0**
Cumulative RTB* increase	0.0	0.0	0.0	0.1	0.1	**0.2**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	5.0
High	6.2

Figure 70 - investment costs

The costs are at the higher end of the Gartner range due to the need for continual enhancement to manage a significant increase in the frequency, complexity and volumes of data exchanged between the ESO, DSOs and TOs as the need for whole system coordination increases and competition emerges in transmission.

5.2.8. Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
Level of investment required in planning and outage data exchange will depend on the nature of the ESO / DSO relationship, which is still evolving. Our working assumption is that the relationship will align least regrets with the coordinated and collaborative approach described by the future worlds 'world B'.	• Engage closely with the business and monitor development of the whole system approach.	2	1
Each DSO may have separate systems for logging outage plans, so there may be difficulties interfacing and sharing data.	• Work closely with DNOs in design phase to ensure common design standards. Share/promote use of the new TOGA.	5	1

5.2.9. Options

Option(s)	Pros	Cons
Not invest in this area		• Does not facilitate a whole system approach to outage planning. • Does not facilitate the ambition to work more closely with DNOs and DERs to facilitate network access. • Does not support infrastructure and asset visibility. • Leaves operational tools unsupported. • Increases cyber security risk. • Legacy models of data exchange will be unable to manage increased volumes of data.
Invest in stand-alone tools.	• Facilitates a whole system approach to outage planning. • Facilitates the ambition to work more closely with DNOs and DERs to facilitate network access. • Maintains reliability of operational tools. • Reduces cyber security risk. • Facilitates exchange of greatly increased volumes of data.	• Does not support infrastructure and asset visibility. • Tools would continue to operate with separate data sources, making dealing with an increasing workload more difficult. • Inconsistent user experience. • Lack of scalability. • Increased implementation cost due to lack of reuse of enabling technologies.
Update tools and integrate with digital engagement platform and data & analytics platform	• Supports infrastructure and asset visibility in line with the key findings of the EDTF. • Facilitates a whole system approach to outage planning. • Facilitates the ambition to work more closely with DNOs and DERs to facilitate network access. • Maintains reliability of operational tools. • Reduces cyber security risk. • Facilitates exchange of greatly increased volumes of data.	

Option(s)	Pros	Cons
	• Modelling tools would operate with the same data sources, mitigating an increasing workload. • Enables high and consistent customer experience. • Allows for scalability of investment. • Reduced cost from reuse of enabling technologies.	

5.3. 360 Offline network modelling

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

5.3.1. Overview

Transmission analysis is carried out from ten years ahead through to real-time and post event to help design and run the network as securely and economically as possible. The offline network modelling tools deliver the day-to-day analysis required to operate the transmission system in a safe and secure manner, as well as deliver the Electricity Ten Year Statement (*ETYS*) and ENTSO-E reporting

5.3.2. Current state

Offline network modelling currently uses tools and datasets for different purposes, including:

- Offline Transmission Analysis (OLTA): based around the Digsilent Powerfactory analysis tool.
- Offline Stability Analysis (OFSA): based around the Powertech analysis tool.
- Probabilistic Boundary Analysis Tool (PBAT): an experimental tool that could either be productionised or the capability included within one of the existing modelling tools.
- PSSE: an alternative transmission analysis package used for ENTSO-E reporting.
- BID3: used for *NOA* modelling (see IT investment 390 *NOA* enhancements).

The increasing complexity and frequency of analysis means continual investment is needed in the infrastructure and software to maintain and improve performance. Significant investment has been made in RIIO-1 to enhance the capabilities of the tools and this trend is anticipated to continue in RIIO-2.

A lot of data validation is carried out manually. In RIIO-1 we have increased efficiency through automation of selected processes, and we will continue to build on this in RIIO-2.

5.3.3. Case for change

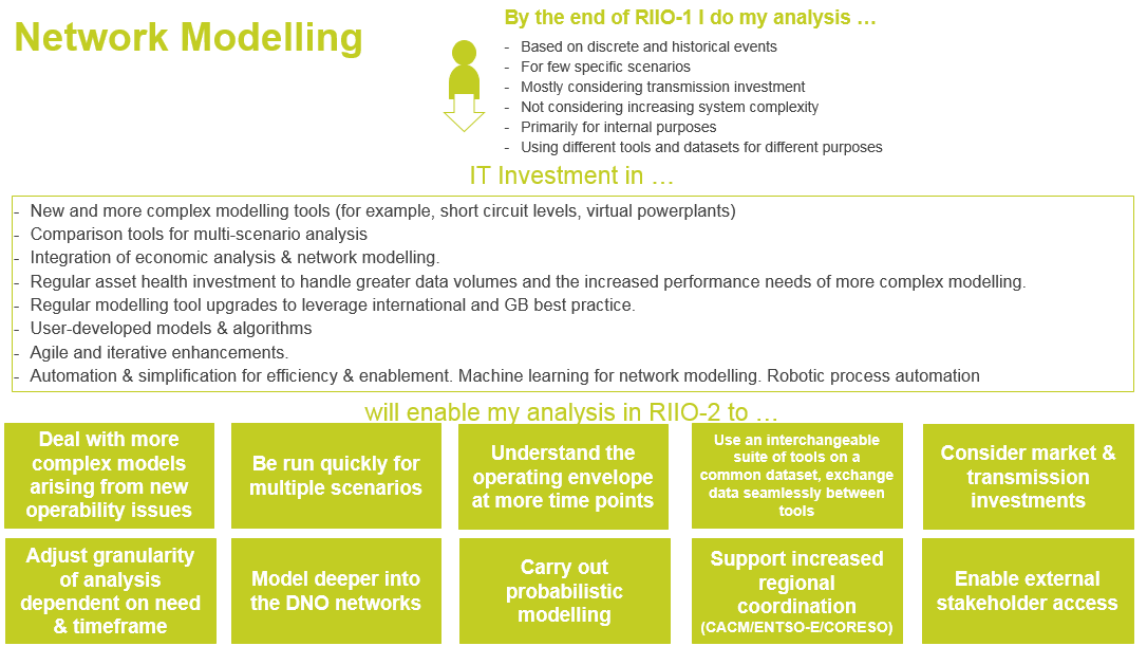

Figure 71 - Use case, investment and outcome expectation

We will integrate IT investments 390 *NOA* enhancements and 360 Offline network modelling tools to give a suite of tools using a common dataset. This user journey covers both areas.

5.3.4. Roadmap

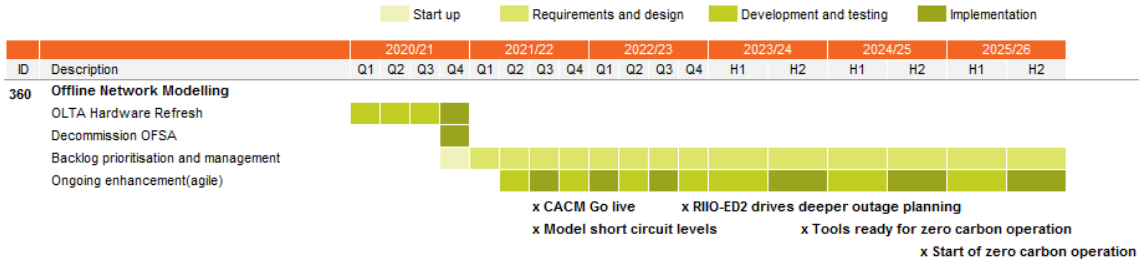

Figure 72 – Delivery plan

5.3.5. Future state

The offline network modelling tools will require enhancement throughout the RIIO-2 period to provide deeper outage planning and optimisation of transmission and distribution assets.

We plan to integrate our offline modelling tools with IT investment 220 Data and analytics platform. This will give an interchangeable suite of tools using a common dataset, and seamless exchange of data between tools, including the analysis tools described in IT investment 390 *NOA* enhancements. This will allow us to adjust the level of analysis as required.

Better performance will be needed to handle increased data volumes, more frequent modelling closer to real time and instant analysis of multiple scenarios. We will continue to invest in infrastructure and software upgrades to facilitate this. This will also allow us to use international best practice included in new releases.

We will use enhanced or new tools to allow more complex modelling arising from operability challenges (for example short circuit levels, virtual powerplants, probabilistic modelling, multi scenario analysis) and to support development of a regime for an integrated offshore grid. This will also include user-developed models and algorithms. We

will continue to invest in automation and simplification for efficiency and data validation and will consider the use of machine learning to improve modelling. We will use an agile and iterative development approach where possible.

5.3.6. Approach

This investment line is related to *NOA* enhancements in network modelling and analysis.

We will follow a similar best of breed approach, combining commercial software and in-house developed analytic software using the same set of data science tools supplied by the data and analysis platform.

We will build upon IT Investment 220 Data and analytics platform to enable an interchangeable suite of tools to utilise a common dataset.

5.3.7. Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	1.2	0.8	0.8	2.0	0.8	**5.6**
Opex	0.3	0.2	0.2	0.5	0.2	**1.4**
Total	**1.5**	**1.0**	**1.0**	**2.5**	**1.0**	**7.0**
Cumulative RTB* increase	0.0	0.0	0.1	0.1	0.2	**0.3**

*RTB - run-the-business on-going opex

Gartner benchmark range

Low	4.1
High	12.0

Figure 73 - investment costs

Expectations of costs for this investment line fall slightly below the centre of Gartner's range due to synergies with IT investment 220 Data and analytics platform.

5.3.8. Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
High level of uncertainty about how modelling tools will need to evolve in future due to changing needs and increased understanding of issues.	• Ensure regular review of requirements throughout RIIO-2 period. • Deploy proof of concept tools as early as possible to gain understanding of modelling needs. • Employ agile delivery principles and flexible, modular applications. • Monitor international practice and engage with other network utilities.	2	1

Risk	Mitigation(s)	Likelihood	Impact
It is assumed that NGET will continue to use the OLTA system. If this changes, ESO running costs will increase.	• Engage with NGET on future plans.	2	1
It is assumed that Scottish Power Transmission (SPT) will continue to use the Digsilent Powerfactory product. If this changes, interfacing costs may increase.	• Engage with SPT on future plans.	2	1
It may prove difficult to achieve a common dataset for all modelling requirements. If so, costs may increase due to more complex implementation	• Understand data needs early in project life, • Have data stewards and a data centric culture supported by data management tools in data and analytics platform	3	1
It may not be possible to achieve the appropriate balance of accuracy, complexity and commercial viability in respect of third party models.	• Monitor international practice and engage with other network utilities. • Engage with other network utilities and network customers.	3	1

5.3.9. Options

Option(s)	Pros	Cons
Not invest in this area		• Puts at risk 2025 ambition to be able to operate a carbon free electricity system. • Does not enable modelling of the increasing complexity of the power system. • Modelling tools would continue to operate with separate data sources, making dealing with an increasing workload more difficult. • Leaves operational tools unsupported. • Increases cyber security risk.
Invest in standalone tools.	• Supports the 2025 ambition to be able to operate a carbon free electricity system. • Enables modelling of the increasing complexity of the power system. • Maintains reliability of operational tools.	• Modelling tools would continue to operate with separate data sources, making dealing with an increasing workload more difficult. • Does not enable holistic decision-making. • Does not enable adjustment of the level of analysis.

Option(s)	Pros	Cons
	• Reduces cyber security risk.	
Invest in tools and integrate with data & analytics platform	• Supports the 2025 ambition to be able to operate a carbon free electricity system. • Enables modelling of the increasingly complex power system. • Maintains reliability of operational tools. • Reduces cyber security risk. • Modelling tools would operate with the same data sources, thus mitigating an increasing workload. • Enables holistic decision-making. • Enables adjustment of the level of analysis.	

5.4. 380 Connections platform

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

5.4.1. Overview

We propose building a customer connections hub, providing a single point of contact for connections to electricity networks that will guide customers through the connection process. The hub will advise customers of capacity opportunities on both the distribution and transmission networks.

5.4.2. Current state

The process is carried out manually and is perceived as confusing by smaller parties that wish to connect.

5.4.3. Case for change

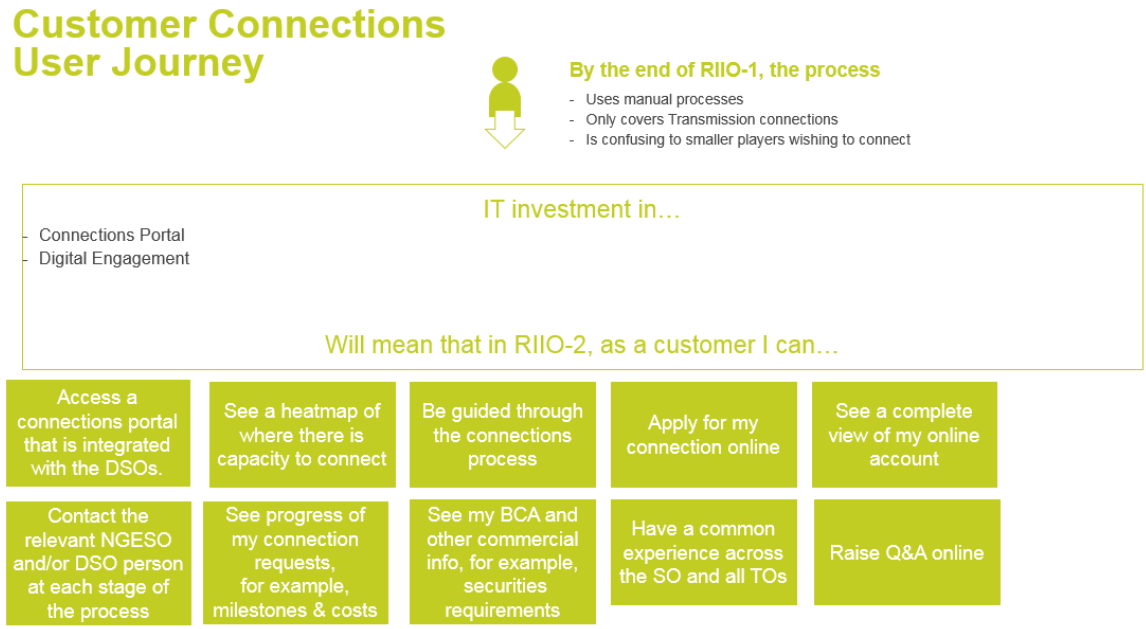

Figure 74 - Use case, investment and outcome expectation

5.4.4. Roadmap

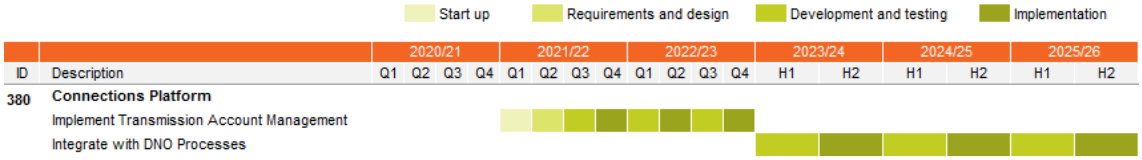

Figure 75 – Delivery plan

5.4.5. Future state

The hub will provide consistency in applying for connection across Great Britain, with standard data requirements, costs and technical requirements. Through RIIO-2 we will work with stakeholders to develop this tool so that it provides a one stop shop for all connection-related information, such as signed agreements, charges, and operational notifications. It will be fully integrated with our digital engagement and customer relationship management tools to provide a seamless experience to customers and stakeholders.

We will work collaboratively with TOs to create a consistent and transparent solution, reusing what we can.

We propose building this incrementally, between 2021/22 and 2022/23. Initially, it will provide a central repository of information about the connections process and in time give customers information on available capacity at each grid supply point (GSP). This will take the form of a heatmap indicating where there is capacity. It could be extended to show the need for balancing services.

The hub will also allow customers to access their account information online, access information about their connection agreements, and track the progress of their connections.

From 2023/24, we will also add the capability to integrate with other network organisations' websites and tools.

Investing in this also aligns with the EDTF key finding in the area of infrastructure and asset visibility, identifying the location of system assets and infrastructure and their capabilities, to inform system planning and management.

5.4.6. Approach

We will build a new connections hub utilising IT investment 250 Digital engagement platform, providing a single user experience. The connections platform will provide a consistent set of Application Programming Interfaces (APIs), allowing customers to integrate with their own internal processes.

The connections platform will be based on a master connections database built on the IT investment 220 Data and analytics platform.

Artificial intelligence will increase the level of automation and self-service. Natural language processing techniques will help participants interpret and understand the various connection specification standards without intervention.

We anticipate that the connections platform will be primarily cloud-based, inherited from the underlying platforms.

5.4.7. Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	0.7	0.7	0.2	0.1	0.1	**1.8**
Opex	0.5	0.5	0.1	0.1	0.1	**1.2**
Total	**1.2**	**1.2**	**0.3**	**0.2**	**0.2**	**3.0**
Cumulative RTB* increase	0.0	0.1	0.1	0.1	0.1	**0.4**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	2.0
High	5.0

Figure 76 - investment costs

Expectations of costs for this investment line fall slightly below the centre of Gartner's range due to synergies with IT investment 250 Digital engagement platform.

5.4.8. Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
That there are many industry initiatives seeking to develop portals simultaneously and that this is an inefficient and uncoordinated approach (e.g. EDTF, BEIS code governance reform review, BEIS/Ofgem work on smart systems and flexibility). This may mean a delay to something being built for the whole industry plus potentially confusing and substandard product due to lack of coordination.	• We will work collaboratively with TOs to create a consistent and transparent solution, reusing what we can. • Engage with industry via customer seminars.	3	1

5.4.9. Options

Option(s)	Pros	Cons
Not invest in this area		• Does not enable the ambition to transform the connections process. • Does not enable the digitalisation of the energy system. • Does not provide a more user-friendly, inclusive and tailored experience for customers. • Does not enable achievement of efficiencies in the pace of decision making. • Process would remain manual and require additional resources. • New participants would continue to find it difficult to connect, driving up workload and potentially creating a barrier to entry. • Does not support infrastructure and asset visibility.
Invest in new stand-alone tools	• Enables the ambition to transform the connections process. • Supports the digitalisation of the energy system, as recommended by the EDTF. • Provides a more user-friendly and tailored experience for customers. • Enables efficiencies in the pace of decision-making. • Enables automation of processes. • New participants would find it easier to connect and a barrier to entry would be removed. • Need for additional resource to manage the process would be mitigated. • Supports infrastructure and asset visibility.	• Inconsistent user experience. • Lack of scalability. • Increased implementation cost due to lack of reuse of enabling technologies.
Invest in new tools and integrate with	• Enables the ambition to transform the connections process.	

Option(s)	Pros	Cons
digital engagement platform	• Supports the digitalisation of the energy system, as recommended by the EDTF. • Provides a more user-friendly and tailored experience for customers. • Enables efficiencies in the pace of decision-making. • Enables automation of processes • New participants would find it easier to connect and a barrier to entry would be removed. • Need for additional resource to manage the process would be mitigated. • Enables high and consistent customer experience. • Allows for scalability of investment. • Reduced cost from reuse of enabling technologies. • Supports infrastructure and asset visibility in line with the key findings of the EDTF.	

5.5. 500 Zero carbon operability

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

5.5.1. Overview

The closure of conventional thermal power stations and the loss of the support that these generators provided to the networks is just one of the changes expected to impact the operability of the power system through RIIO-2. Our proposals enable us to address these and allow us to operate a zero carbon power system by 2025.

Increased capability is needed to help our Control Centre maintain power system stability in a low carbon world. To achieve this efficiently, it will be necessary to supplement new services for network stability and implement a wide area monitoring and control system, based on the recently completed enhanced frequency control capability (EFCC) innovation project[3].

5.5.2. Current state

The EFCC innovation project was designed to find a solution to the challenge of operating the system in a low carbon environment. Project partners included: GE Renewable Energy, the University of Manchester, the University of Strathclyde, Belectric, Flexitricity, Centrica/EPH, Ørsted and Siemens Gamesa Renewable Energy. The project developed and tested the first wide area Monitoring and Control System (MCS) of its kind in GB. Through trialling the MCS, the project has demonstrated its flexibility for coordinated, fast frequency response, allowing a wide range of technologies to participate in managing system frequency including:

- solar PV.
- battery storage.
- wind power.
- thermal generation.
- Demand Side Response (DSR).

5.5.3. Case for change

Traditional, large rotating power generators provide inertia (the resistance of an object to any change in motion) which acts as a natural aid in maintaining frequency stability and provide an inherent electrical support to the network. Many renewable energy technologies do not provide inertia, meaning they cannot help to maintain system frequency in the same way. The increased risk of rapid changes to frequency could lead to a risk of disturbance on the electricity network. As a result, we will require a greater volume and speed of frequency response and other capabilities to keep the system stable.

New, significantly faster, coordinated response solutions using renewables, demand-side resources, and other technologies need to be developed.

[3] More information can be found on the EFCC here: https://www.nationalgrideso.com/innovation/projects/enhanced-frequency-control-capability-efcc

5.5.4. Roadmap

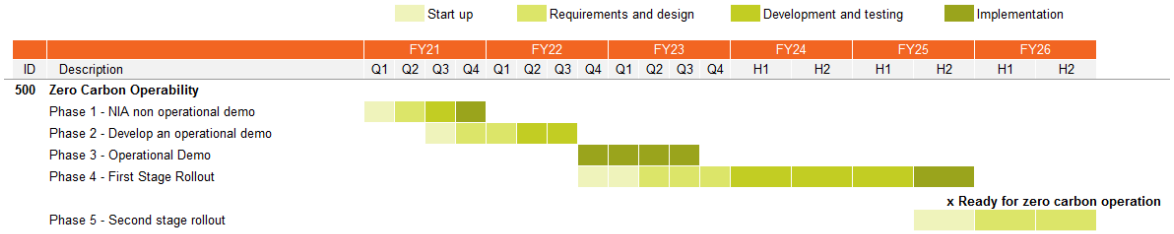

Figure 77 – Delivery plan

A phased approach to any potential implementation of the MCS is needed which can take account of the development and performance of stability related balancing services This will include a full assessment of the how the MCS will operate on the live electricity system which will help to increase the technical readiness of the system before any potential roll out. Consideration must also be given to a new commercial framework with service providers, and IT interfaces with the ESO's balancing system before any implementation to understand the impact and necessary interfaces.

This phased approach will help the transition of this complex scheme to be carefully managed and coordinated with other industry strategies. To mitigate risk, the implementation project will follow a five-phase approach, which is based on that set out in more detail in the EFCC Closure Report[4], chapter 11.

- NIA demo (non-operational)
- develop an operational demo
- operational demo
- first stage rollout
- second stage rollout.

5.5.5. Future state

When a variance in frequency or voltage occurs on the system, it needs an instantaneous response. As this frequency response is being calculated and deployed, there is a difference between the frequencies at the points where these technologies connect.Where there is a network disturbance, voltages will look very different at different parts of the electricity system. The MCS provides the bridge between the technologies and the ESO and automatically deploys the appropriate response at the right time to support the stability of the power system. The MCS also provides greater visibility of what is happening on the grid by using real-time data.

The MCS monitors the electricity grid at a regional level and coordinates regional response from a range of service providers. The MCS can detect an issue and trigger a response from multiple resources within a fraction of a second that optimises their performance characteristics. This allows the network to operate with increasing volumes of non-synchronous generation by providing an adaptable control platform which can access the response capabilities from a range of non-synchronous technologies (within rapid timeframes ~0.5 second).

We will utilise the phased approach described above to implement an initial MCS capability by 2025 to enable zero carbon operation and start work on full capability for completion after the RIIO-2 period. Due to its high criticality, we anticipate it will require critical national infrastructure (CNI) levels of security and availability.

[4] The EFCC Closure Report can be found here: https://www.nationalgrideso.com/document/144441/download

Stability services will be integrated into control room tools, for example the new dispatch solution under IT investment 180 Enhanced balancing capability in Theme 1. The MCS will rely on the inertia monitoring capability being delivered by the IT investment 130 Emergent technology and system management, and the frequency monitoring capability being delivered by the IT investment 170 Frequency visibility.

5.5.6. Approach

The MCS will have high availability and resilience and will be geographically diverse. The concept of 'graceful degradation' has been incorporated into the design so the system will continue to operate in the event of a single component failure, with a reduced level of performance using the remaining available components.

While the EFCC innovation project sought to test and prove the MCS technology, it did so on a small scale and focussed on frequency control. The implementation project will therefore use significant trialling/proof of concept stages to verify the solution before commiting to full implementation.

The MCS will be based in our CNI estate in our data centres and will use the secure operational telecoms network provided by the TOs for communication with remote sensors and controllers. The network communication requirements will be assessed and agreed in phases 1 and 2. The phased approach and rollout strategy will seek to minimise data volume and speed requirements. Full capability will only be deployed in Phase 5, based on learnings from the first 4 phases.

We will implement the MCS as a bespoke application with an external partner. The early phases of the project will determine the appropriate procurement approach. The implementation timescales may vary dependent on the approach chosen. The timescales are also dependent on obtaining NIA funding to complete Phase 1 in RIIO-1, and also commencement of Phase 2.

5.5.7. Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	4.0	5.2	7.0	3.9	2.3	**22.4**
Opex	0.4	0.6	0.8	0.4	0.3	**2.5**
Total	**4.4**	**5.8**	**7.8**	**4.4**	**2.5**	**24.9**
Cumulative RTB* increase	0.0	0.5	1.1	2.0	2.5	**6.0**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	24.9
High	24.9

Figure 78 - investment costs

Within ESO, there are systems or activities that are niche to our industry and, in some cases, to our organisation and market, such as our RDPs. These cannot easily be benchmarked by Gartner. In this instance, Gartner passes through our estimates, as they are the most accurate values available

The EFCC project developed a series of implementation estimates based on different *FES* scenarios and the relative balance of transmission and distribution connected participants. The estimates are based on the 2017 *FES Consumer Power* scenario with 80 per cent transmission connected and 20 per cent distribution connected providers. If the number of distribution connected providers is greater, costs could increase significantly.

The five year cost ranges identified by the EFCC project ranged from £19 million totex for the 2017 *FES Steady State* scenario with 100 per cent transmission connected providers, to £45 million for the 2017 *FES Consumer Power* scenario with 50 per cent transmission and 50 percent distribution connected providers.

5.5.8. Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
The system requires fast communications and we are dependent on a third party to deliver these.	• The network communication requirements will be assessed and agreed in phases 1 and 2. • Delay rollout and rely on balancing services at higher net cost.	2	1
Cyber security vulnerability, leading to unauthorised operation.	• Cyber security vulnerability assessment showed there are no major weaknesses. This will be reassessed as the system is scaled up. Phase 1 of the project will define a cyber security benchmark. If cyber issues could not be resolved, we would delay rollout and rely on balancing services at higher net cost.	2	1
While the technology has been tested through the EFCC innovation project, it has not been implemented on a larger scale and with increased complexity. Costs and timescales may therefore increase.	• There will be project check points following the end of each phase of the project to assess whether it should progress to the next phase.	3	2
The current design of the MCS could require a significant volume of data transfer, leading to additional investment in the communications network.	• Phased approach and rollout strategy will seek to minimise data volumes. Full capability will only be deployed in Phase 5, based on learnings from the first 4 phases.	3	3
Demand side participation is higher than estimated. If the number of distribution connected providers is greater than the assumed 20%, costs could increase significantly.	• Utilise the phased approach and monitor types of participant wishing to connect.	2	3
Commercial arrangements for use of the system cannot be agreed with sufficient providers	• Include development of commercial terms in the criteria for project progression.	2	2

Risk	Mitigation(s)	Likelihood	Impact
The system measurements (e.g. inertia monitoring) required for effective system performance cannot be delivered	• Include development of inertia monitoring in the criteria for project progression.	1	1

5.5.9. Options

Option(s)	Pros	Cons
Not invest in this area		• Puts at risk 2025 ambition to be able to operate a carbon free electricity system. • Increased operational risk from low levels of synchronous generation and inertia. • Increased operational risk arising from power system stability issues. • Unable to manage regional stability issues in a coordinated manner. • Delays the transition to whole electricity system operation. • Unable to benefit from learnings of the EFCC project. • Potential net costs of up to £500 million by 2028 due to increased market intervention by the ESO to balance the electricity system.[5]
New enhanced capability	• Facilitates the 2025 ambition to be able to operate a carbon free electricity system. • Reduces operational risk from low levels of synchronous generation and inertia. • Reduces operational risk from power system stability issues. • Enables management of regional stability issues in a coordinated manner. • Facilitates the transition to whole system operation.	

5 EFCC Closure Report, p52.
https://www.nationalgrideso.com/document/144441/download

Option(s)	Pros	Cons
	• Enables the benefits of the learnings of the EFCC project to be realised. • Potential net benefits of up to £500 million per year by 2028 due to reduced market intervention by the ESO to balance the electricity system.[6]	

6 EFCC Closure Report, p52.
https://www.nationalgrideso.com/document/144441/download

6. Digitalisation and open data investments

This section includes investments defined in our Business Plan, in the chapter Digitalisation and open data unlocking zero carbon system operation and markets.

6.1. 250 Digital engagement platform

Current stage:

Scoping	Start up	Requirements and design	Development and testing	Implementation

6.1.1 Overview

This investment, mentioned in the chapter 8, Digitalisation and open data unlocking zero carbon system operation and markets, will enable a single point of access for all ESO data and services, including the markets, connections, digitalised Grid Code management and data and analytics platform. It sits at the heart of our vision for digital capability across all our themes, providing a common engagement experience for stakeholders.

6.1.2 Current state

We started investing in this area during RIIO-1, developing pockets of functionality through customer relationship management (CRM) capabilities. We will also be allowing customers access to more of our data via ESO websites which are not currently part of the core ng.com platform.

We identified demand from our customers for this service across most of our market and operational areas such as network charging and access, customer connections, contract management, commercial operations and others. Ease of access and user experience are key requirements.

6.1.3 Case for change

Data access and submission is expected to increase for both our critical and supporting processes. This will result in a corresponding increase in data sources, volumes and update frequency. Enabling this increase in stakeholder engagement (incorporating smaller GB and European market participants and DNOs / DSOs) and ensuring quality and security of data, will require a significant investment across the RIIO-2 period.

To enable efficiencies across similar functionalities, we need to investment in application consistency during RIIO-2. This will also improve our customers' user experience and our own productivity in this area. Some potential benefits are shown in Figure 79 - Use case, investment and outcome expectation and Figure 80 - Use case, investment and outcome expectation.

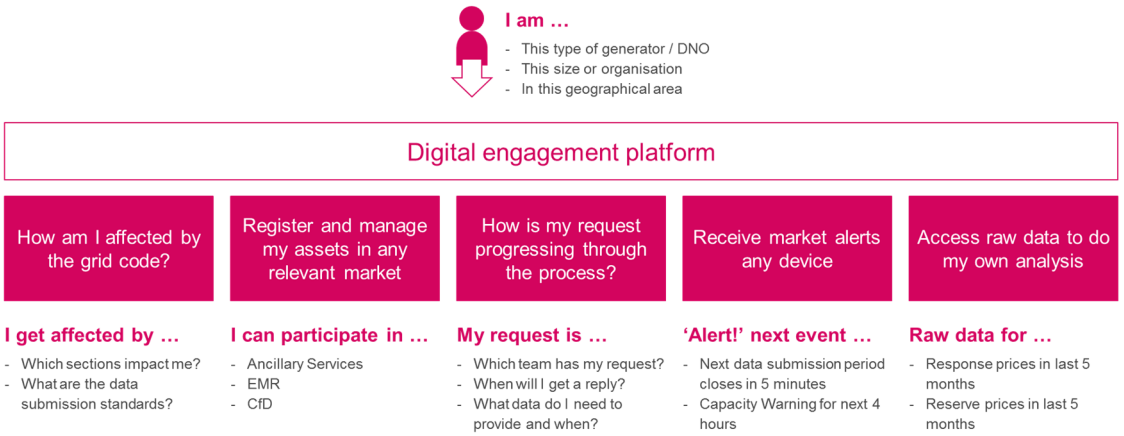

Figure 79 - Use case, investment and outcome expectation

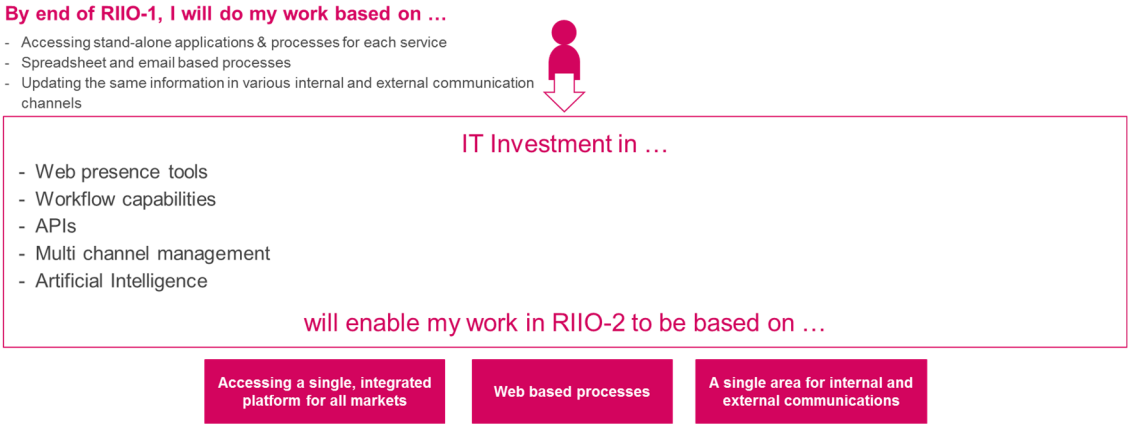

Figure 80 - Use case, investment and outcome expectation

6.1.4 Roadmap

The data portal investment from RIIO-1 will be integrated with our CRM and operational systems. We will build supporting tools for ensuring data quality, and to provide search and knowledge management. With the large increase in participation and data, investment will also be needed to provide more responsive data access management, and to meet publication policy.

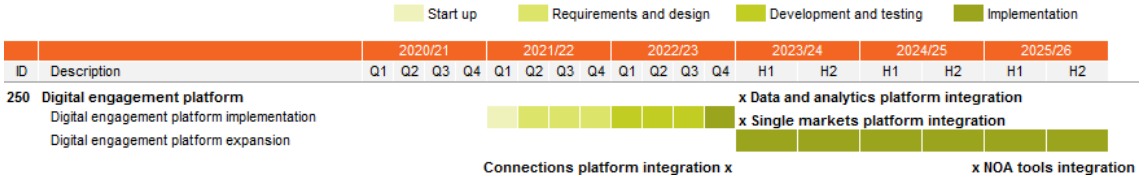

Figure 81 – Delivery plan

6.1.5 Future state

Here, investment centres on technologies to support digital market engagement. A range of approaches are required, from enhanced publication of raw data, through to publication of insights.

We propose a single point of access into the ESO systems and external-facing processes, providing secure, open access to data, compliant with data classification policies and standards. We will consolidate our ESO data publication and reporting channels, offering stakeholders access to our data, including multi device capability and industry standard APIs.

New tools will be introduced to support document management, collaboration, digital rights management, version management and workflow planning, providing clarity on as areas including code modifications and connection contracts. This investment will ensure

all external processes can be driven and updated from this platform, connecting seamlessly to our internal critical systems, making use of our IT investment 220 Data and analytics platform.

As mentioned, this investment will ensure efficiencies across otherwise overlapping investments as shown in next table:

Use Case	API / Multi-channel	Alerts	Doc. Mgt.	AI targeted content	Policy Enforcement	Data Quality Tools	Identity and Access Mgt.	Workflow Mgt.
Data and analytics platform	Y	Y	Y	N	Y	Y	Y	N
Single markets platform	Y	Y	Y	Y	Y	Y	Y	Y
Connections	Y	Y	Y	N	Y	Y	Y	Y
Outages	Y	Y	Y	Y	Y	Y	Y	Y
Codes management	N	Y	Y	Y	Y	Y	Y	Y

Figure 82 – Investment efficiency opportunities

6.1.6 Approach

We will develop a new digital engagement platform to meet the needs of the RIIO-2 programme, delivering common presentation capabilities for the component projects of the programme.

By default, the digital engagement platform will use low cost, open source, commodity building blocks and standards to control cost and give maximum flexibility.

New solution components will be chosen after careful research and appropriate formal selection processes.

First, we will identify a suitable web development framework and portal server (often called a digital experience platform or DXP - DXP is used here to avoid confusion with the wider digital engagement platform). This enables the development and management of modularised web UIs that can be combined into the sophisticated web UIs for operational use.

We will buy an API manager package to control the many service APIs we will present externally and internally.

We will draw on external partners' capability during implementation of the digital engagement platform, but we will develop deep in-house capabilities for the RIIO-2 programme and beyond.

The digital experience platform will be primarily cloud-based with deployment to CNI compliant hybrid cloud as well as public cloud for less critical workloads.

The digital engagement platform will sit in the ESO SOA to standardise and automate access for the RIIO-2 business service.

6.1.7 Costs

Investment (£m)	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capex	1.3	1.3	1.1	0.6	0.0	**4.2**
Opex	0.8	0.8	0.7	0.4	0.0	**2.8**
Total	**2.1**	**2.1**	**1.8**	**1.1**	**0.0**	**7.0**
Cumulative RTB* increase	0.0	0.1	0.2	0.3	0.3	**0.9**

*RTB - run-the-business on-going opex

Gartner benchmark range	
Low	6.2
High	11.1

Figure 83 - investment costs

Our costs reflect synergies between investments required for IT investments 400 single markets platform, 330 Digitalised code management, 380 Connections platform and 320 EMR and CfD improvements. These synergies allow us to estimate lower costs than otherwise, that is if we were to address all the use cases individually.

6.1.8 Risks

Risks specific to this investment are listed below. Generic portfolio level risks and a description of the scoring method for likelihood and impact can be found in Appendix C.

Risk	Mitigation(s)	Likelihood	Impact
Requirements from market participants are unclear or conflicting.	• Engage market participants regularly via design authority and show and tells.	3	1

6.1.9 Options

Option(s)	Pros	Cons
Not invest in this area		• Does not enable easy and economic data sharing with our customers. • Creates staff overheads and technical debt as it addresses engagement problems with inefficient processes and workarounds. • Requires higher level of investment in other areas to make up for engagement inefficiencies. • Puts other prioritised costumer value areas in RIIO-2 plan at risk. • Does not enable transparency. • Does not meet new customer data needs in a timely way.

Option(s)	Pros	Cons
		• Maintains low costumer experience. • Increases cyber security risk.
Invest in legacy tools		• Does not support easy and economic data sharing with our customers. • Creates staff overheads and technical debt as it addresses engagement problems with inefficient solutions and processes. • Duplicates investment in other areas to make up for lack of engagement standard solutions. • Puts other prioritised costumer value areas in RIIO-2 plan at risk. • Does not enable transparency. • Does not enable meeting new customer data needs in a timely way. • Maintains low costumer experience. • Increases cyber security risk.
Update tools and integrate with data platform, network control and enhanced balancing capabilities	• Enables transparency. • Enables easy and economic data sharing with our customers. • Allows for scalability of investment. • Enables objectives of other prioritised costumer value areas in RIIO-2 plan. • Introduces engagement standards. • Enables high and consistent costumer experience. • Enables introduction of efficient processes. • Enables quicker response to market needs.	

7. Shared investments: business services

7.1. Executive summary

The National Grid group delivers business services to ESO via a shared service model with support functions providing delivery of common services such HR, finance, IT, legal and procurement. They support the delivery of our core activities, helping us to find and retain our people, provide financial stewardship, ensure legal compliance and manage our IT systems.

In RIIO-2, as a group, we will invest £75 million (£12 million allocation for ESO) to maintain and evolve the IT systems delivering these business services.

	2021/22	2022/23	2023/24	2024/25	2025/26	Group Total
Digital and web	0.5	1.9	0.0	0.0	1.5	3.9
Finance	9.6	10.1	7.9	8.1	10.9	46.7
HR	2.1	1.6	2.2	2.0	1.6	9.4
Procurement	2.5	1.2	0.9	0.7	2.9	8.3
Other apps.	1.2	3.5	1.3	0.4	0.8	7.1
Total	**15.9**	**18.3**	**12.3**	**11.3**	**17.7**	**75.5**

Figure 84 - Group capex investment in business services, 18/19 pricing, £ million, opex not shown.

This investment supports the delivery of 1.1 per cent year-on-year efficiency improvements across the support functions through adoption of new capabilities. This represents almost three times the current UK trend for productivity improvement.

The investment also ensures the ongoing maintenance of our systems, without which the investments made in RIIO-1 would become outdated and inefficient and non-compliant with legislation and regulations, exposing our systems and data to an increased cyber risk and operational failure.

The investment has been independently benchmarked by Gartner to be within our peer group range.

In RIIO-1 we focused on rationalising our systems and establishing core standard technology platforms that allow the efficient delivery of business services. We have now established our core enterprise resource planning (ERP) services on SAP S/4HANA, our employee services on SAP SuccessFactors, our service desk functions on ServiceNow, and we have consolidated all risk functions on to the RSA Archer governance, risk management, and compliance (GRC) platform.

This strategy has met the immediate needs of the business and put in place platforms for continued growth. Wherever possible we have used these technologies without customisation so we can gain maximum benefits from these industry standard platforms as they continue to be evolved by the manufacturers. Our strategy for RIIO-2 is to keep platforms current through incremental investment exploiting new functionality to further increase our efficiency, thereby avoiding the need for major system replacements with associated cost and risk whilst maintaining a secure and controlled ecosystem. This strategy also strengthens our data management capability by adding advanced analytics that come with core platforms, helping minimise the movement of data between systems.

7.2. Introduction

The National Grid group delivers business services via a shared service model with support functions that provide the efficient delivery of common services such as HR, finance, IT, legal and procurement to all the National Grid group businesses. This creates economies of scale in delivering these services. Internally, these support functions are organised into services lines within the organisation.

Providing modern, well maintained IT solutions to our support functions is fundamental to enabling high quality, cost effective and efficient services and to deliver their goal of a 1.1 per cent year-on-year improvement in operating productivity, which represents almost three times the current UK trend for productivity improvement.

It is critical that we invest in the ongoing maintenance of our systems, without which the investments made in RIIO-1 would become outdated, inefficient and non-compliant with legislation and regulations, exposing our systems and data to an increased cyber risk and operational failure. During RIIO-1 we made major investments in response to new legislation (such as GDPR), changing financial reporting obligations, and improving our financial and operational risk control frameworks. Maintaining this compliance and responding to new obligations and the ever increasing cyber threat is of critical importance to us.

Business services consists of five themed sections which are addressed in both this background section as well as the optioneering and justification sections of this document.

Business services themes
• Finance systems
• Procurement systems
• HR and workforce systems
• Digital and web systems
• Other core systems

Figure 85 - business services

7.3. Background information

Overarching back office technology strategy

In RIIO-1 we focused on rationalising our systems and establishing core technology platforms that allow the efficient delivery of business services.

This strategy has met the immediate needs of the businesses and put in place platforms for continued growth. Wherever possible we have used these technologies without customisation so we can fully leverage these industry standard platforms as they continue to be evolved by the manufacturers. Our strategy for RIIO-2 is to keep platforms current through incremental investment, avoiding the need for major system replacements with associated cost and risk, exploiting new functionality to further increase our efficiency, whilst maintaining a secure, compliant and controlled ecosystem.

Through RIIO-1 we responded to the challenge from Ofgem to reassess our IT asset health policies by extending the technical lives of our IT infrastructure assets, accepting higher levels of risk whilst maintaining levels of availability. Due to the increasing demands placed on the system, coupled with the increasing threat of cyber-attacks on our systems, we decided to review the IT asset health policy to mitigate this. Taking on these learnings, we have updated our IT asset health policies, which have been reviewed by independent IT experts Gartner who confirmed that they are in line with industry practice. In RIIO-2, it is important that we continue to invest in the back office applications

in line with these polices to support further improvements in process, automation and data to drive insights in delivering against further efficiencies whilst mitigating the risk of cyber-attacks.

ERP is at the heart of our back office systems strategy in this area. It delivers our core finance, procurement and HR services and is the single source of data for operational and business systems across the organisation. We will continue to remain SAP-centric in our approach to delivering back office services, building on previous investments and leveraging the benefits of an extended SAP platform.

Our current ERP was implemented in 2007, and whilst the underlying software has been kept up to date, its age means that improvements are constrained, for example in relation to mobile use and process automation, where our procurement solution (as an example) is out of support and will not support mobile use. As a result, we moved HR and procurement to market leading SaaS products (SAP SuccessFactors for HR, and Coupa for procurement) in 2018.

We are moving to S/4HANA as our core finance system. SAP has focused on its S/4HANA product, which delivers significant simplification, performance improvements and standard processes while offering much of the same elements as SaaS – providing out of the box, market-leading processes. This product has various subscription-based SaaS offerings, and we expect that as the market for these services matures, the National Grid group would migrate to an SAP SaaS offering midway through the RIIO-2 period, subject to commercial considerations.

The diagram below shows the benefits being achieved through the RIIO-1 investment which need to be maintained and built on throughout RIIO-2.

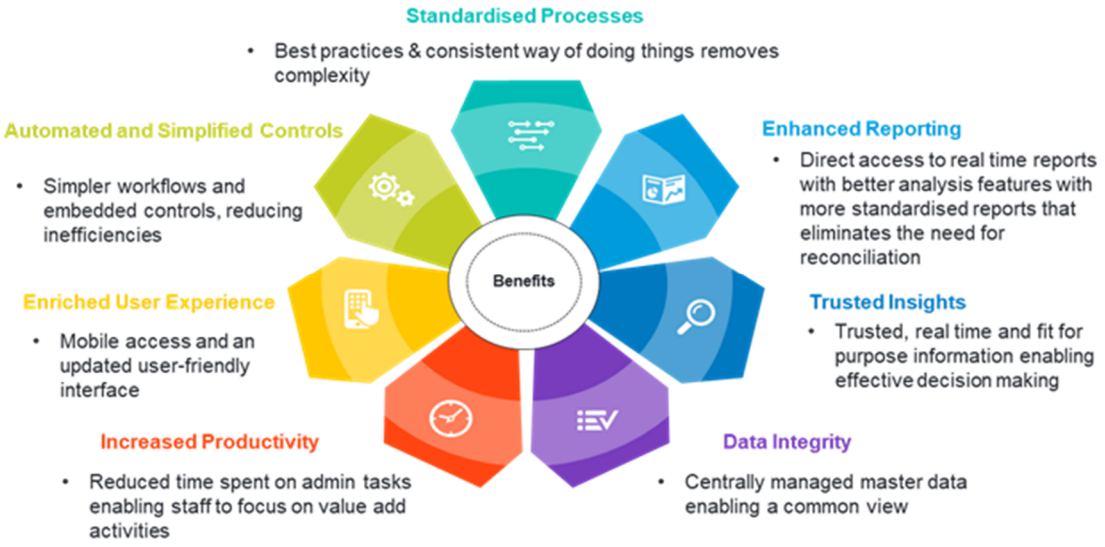

Figure 86 – Benefits built on in RIIO-2

The Y and Z generation, who have grown up in a connected, collaborative and mobile world, will account for over half of the workforce before the end of the RIIO-2 period. This change in workforce balance will redefine corporate culture and expectations of work shifting the business to think mobile first. Our systems will need to support flexible working, a more open and social approach to collaboration, that are increasingly automated, intelligent and thus very data-centric.

Throughout RIIO-2 the benefits of our RIIO-1 investments will be extended as we invest in deepening the digital transformation for the ESO, focusing on:

- Intelligent process automation and mining with machine learning.
- Increasing levels of integrated control.
- Enhanced data management and cleansing.

- Advanced and predictive analytics.
- Forward looking intelligent financial forecasting.

In the Gartner 2019 CIO (chief information officer) agenda for utilities report, they noted the two focus areas – firstly, data analytics (including advanced analytics) and secondly, artificial intelligence, machine learning and innovation. Both these themes are priorities to support optimisation, minimising operations and improving engagement. We have engaged with Gartner on a benchmarking exercise to validate the proposed investments for RIIO-2. Of these, 6 per cent are aligned to artificial intelligence and innovation which is in line with the Gartner benchmark for utilities and 10 per cent are aligned to data and analytics which is close to the lower end of the Gartner range for utilities.

7.4. Technology themes

Technology is developing at an ever increasing pace. Whilst it is difficult to be specific about the technologies we will use, the following business and technology drivers are relevant. Undoubtedly there will be further technology developments that will offer benefits; IT will work with the business to continually monitor developments and explore new opportunities as they arise.

Cloud / software as a service (SaaS)

A significant number of our IT systems for back office functions are already acquired though leasing or subscription - instead of owning the servers and software (e.g. Success Factors - HR, Ariba and Concur - procurement, ServiceNow – Service Desks). This subscription-based model buying SaaS includes hosting and storage plus operational support and maintenance. Unlike a perpetual licence, the SaaS subscription includes updates and enhancements and does not require the National Grid group to provision capital for maintenance, infrastructure or datacentre services.

SaaS offers many advantages including best in class processes, greater reliability at a lower cost, increased agility, and consumption-based licencing.

Data and analytics

The investments in data and analytics through the RIIO-2 period will be focused on consolidating into the digital core and increasing capabilities and functionality through continuous innovation in core tooling. The process moves from opportunity identification, ideation or invention to development, prototyping and finally to a new, valuable tool. New capabilities from cloud analytics and data management products will be continually reviewed. A joined up approach across the business will maximise capability, innovation and operation of the new tools and technologies.

Robotic process automation (RPA) and artificial intelligence

Use of RPA and artificial intelligence will be expanded to enable the more efficient delivery of business services. In the short-term adoption of robotics and basic automation, particularly of data entry or low cognitive activities, will grow. We are already seeing the successful adoption of RPA in our shared service functions and we expect this to expand. In the medium-term, artifical intelligence and machine learning (ML) will become more capable, becoming embedded in our systems and services. This will enable a move to smart process automation (SPA) as an extension of RPA. SPA will allow the additional automation of unstructured data RPA is unable to do today without human support, where ML is used to build capability as the system learns to deal with exceptions and automate more of the processes. Within core finance ML will be expanded and build upon capability delivered in the RIIO-1 period with S/4HANA. Initially the uses will be routine, for example, of advanced conversational web chat agents (chatbots) processing employee queries on behalf of HR. As artifical intelligence becomes more pervasive, this will be the start of a paradigm shift where our systems morph from being workflow-focused in assisting workers towards a model where they are assisting our systems and providing insightful appraisals of business performance, moving towards a more connected ecosystem.

7.5. Finance systems

By the end of the RIIO-1 period, business services plans to have invested in three key areas: ERP, controls, and data and analytics.

During 2018-20, a major business transformation programme, Project One, will deliver a refreshed platform and suite of applications. The core ERP platform will have been transitioned from SAP ECC (enterprise central component) to SAP S/4HANA.

At the time of legal separation, our SAP ECC was 10 years old and was heavily dependent on manual processes to service financial transactions and provide supporting information to all business areas. Investment was required to address the sustainability issues within these systems, as well as providing the improved financial insight and business control to enable the business to scale for future demand.

The configuration of the existing ERP system does not support better processes or controls and is at the end-of-life. An asset health upgrade would be required in the near future and it is not well suited to future cloud migration and operation.

Following detailed analysis of the options we implemented basic functionality of SAP S/4HANA for ESO, followed by the adoption of SAP S/4HANA across the remainder of the National Grid group.

As we modernise our ERP capabilities with S/4HANA (for example automating interfaces to core processes such as procurement through Coupa and HR through SuccessFactors), the ESO will benefit from the development of the platform capability while maintaining an independent instance of data. SAP S/4HANA provides a highly scalable, future-proofed solution that eliminates much of the manual process causing data inconsistency inherent with the legacy SAP ECC solution.

In conjunction to the ERP investment, payroll will have become a managed service and a new travel and expenses solution, SAP Concur, will be implemented. This will see the consolidation of systems across finance into a digital core with best in breed applications forming building blocks for further digital transformation into RIIO-2.

Figure 87 – Key elements of a digital core

As a group, we will invest £47 million in S/4HANA and connected applications, both to maintain the current version of software and to introduce new capabilities.

We will need to maintain our systems to the supported software releases to maintain security and continue enabling seamless connectivity with SaaS solutions. Investment in

the new capabilities (such as artificial intelligence, RPA, ML and data and analytics) will be needed to enable the business to deliver ongoing efficiency saving.

	2021/22	2022/23	2023/24	2024/25	2025/26	Group Total
Banking upgrade	0.0	0.0	0.0	0.0	0.0	0.0
Business planning	0.0	3.0	0.0	0.0	0.0	3.0
Process improvement	0.0	0.0	0.0	0.0	0.0	0.0
Tax reporting and analysis	0.0	0.0	0.0	0.0	0.0	0.0
Enterprise content mgt.	1.0	0.0	0.0	0.0	3.0	4.0
ERP S/4HANA	6.9	6.9	6.9	6.9	6.9	34.5
Making tax digital	0.0	0.0	0.0	0.0	0.0	0.0
Payroll	0.0	0.0	0.0	1.0	0.0	1.0
Portal	0.0	0.0	0.0	0.0	0.0	0.0
RPA platform	1.0	0.3	0.3	0.3	1.0	2.8
SAP analytics cloud	0.0	0.0	0.0	0.0	0.0	0.0
SAP group financial controls	0.0	0.0	0.0	0.0	0.0	0.0
Service management tool	0.0	0.0	0.0	0.0	0.0	0.0
Compliance activities	0.0	0.0	0.0	0.0	0.0	0.0
Treasury mgt. enhancements	0.8	0.0	0.8	0.0	0.0	1.5
Total	**9.7**	**10.2**	**8.0**	**8.2**	**10.9**	**46.6**

Figure 88 - Group capex investments in finance systems, 18/19 pricing, £ million, opex not shown.

7.6. Procurement systems

The major investment during RIIO-1 was the replacement of our legacy procurement purchase to pay system (SAP SRM5) with a new cloud solution Coupa which brought improvements in data, mobility and user experience. We have also invested in the SAP Ariba platform to manage our source to contract and tendering processes ensuring that procurement activities are efficient and compliant.

As a group, we will invest £8 million in this area, maintaining the asset health of the enabling technology and ensuring the continued efficient operation of our procurement solutions.

Within purchase to pay, investments for RIIO-2 will focus on upgrades and refresh of systems to integrate the purchasing and accounts payable functions. Capabilities include: supply management, purchase requisition, purchase order, receiving, invoice reconciliation, and accounts payable. We will invest in artificial intelligence and robotics to automate the contract to award processes, reducing human input and increasing efficiency.

Within the source to contract process area, we will invest in upgrades and refresh of systems to enable maximum benefit and management of procurement spend on goods and services. Capabilities include digital contract management to provide easy access and real time alerts to vendor performance; supplier relationship management to track vendor interactions and drive consistency in interactions with suppliers; and benefits management to accurately track value from strategic contracts and category management activities.

	2021/22	2022/23	2023/24	2024/25	2025/26	Group Total
ARIBA replacement	0.5	1.0	0.4	0.4	0.4	2.8
Fieldglass replacement	0.0	0.2	0.0	0.0	0.0	0.2
Procurement supplier relationship mgt.	0.0	0.0	0.0	0.0	0.0	0.0
Purchase-to-pay upgrade and enhancements	2.0	0.0	0.0	0.0	2.0	4.0
SAP concur upgrade and enhancements	0.0	0.0	0.5	0.0	0.5	1.0
Travel and booking	0.0	0.0	0.0	0.3	0.0	0.3
Total	**2.5**	**1.2**	**0.9**	**0.7**	**2.9**	**8.2**

Figure 89 - Group capex investment in procurement systems, 18/19 pricing, £ million, opex not shown.

7.7. HR and workforce systems

As a group, we plan to invest £9 million in HR-related systems during the RIIO-2 period.

This investment relates to the upgrades and refresh of core HR systems including SAP Success Factors.

	2021/22	2022/23	2023/24	2024/25	2025/26	Group Total
Case management	0.3	0.0	0.0	0.0	0.0	0.3
Data archiving	0.0	0.0	0.0	0.0	0.0	0.0
Digitising learning	0.1	0.1	0.1	0.1	0.1	0.4
HR policy compliance	0.0	0.0	0.0	0.0	0.0	0.0
SuccessFactors upgrade and enhancements	1.6	1.6	2.0	1.9	1.6	8.7
Total	**2.1**	**1.6**	**2.2**	**2.0**	**1.6**	**9.4**

Figure 90 - Group capex investment in HR systems, 18/19 pricing, £ million, opex not shown.

Implemented in RIIO-1, SuccessFactors is a cloud-based human capital management (HCM) system which will be regularly refreshed and updated throughout RIIO-2 by SAP. SuccessFactors is the core foundation upon which we will base future IT investments in HR. This means that we will avoid any major HR systems re-implementation.

Technology is changing the face of HR, so naturally IT is a vital enabler to the realisation of our HR Strategy. The Y and Z generation, who have grown up in a connected, collaborative and mobile world, will account for over half of the workforce before the end of the RIIO-2 period. This change in workforce balance will redefine corporate culture and expectations of work shifting the business to think mobile first. Our systems will need to support flexible working, a more open and social approach to collaboration, that are increasingly automated, intelligent and thus very data-centric. We will need to consider employee experience, enabled by technology, across the full hire to retire lifecycle.

The continued rise of digital technologies and the shifting workforce dynamics are fundamentally changing how our HR functions work. For our people: digitally led, self-enablement services; for our millennial workforce: digitally powered to identify, attract, retain and develop the best people; and for the businesses we serve: driving lower costs through incremental efficiencies and effectiveness.

Building on the investment made in the SuccessFactors platform during the RIIO-1 period, we will continue to increase the benefits from the new functionality the platform provides, particularly focusing on data. This will help deliver the data foundations needed for a data centric HR function with all employee data in a single system. This will a transform ways of working in the years ahead and ensure continued compliance around data risk, control, security and enablement.

Harnessing of advanced analytical technologies will underpin our ability to deliver valuable insights into our people and organisation to empower the businesses to run its operations more effectively. We will continue to embed and grow the transformation investments already made in RIIO-1.

7.8. Digital and web systems

As a group we will invest £4 million to maintain appropriate and valued digital channels and have the right end-to-end processes to improve our capabilities in stakeholder management, customer engagement and data management in a secure way.

	2021/22	2022/23	2023/24	2024/25	2025/26	Group Total
Analytics	0.0	0.0	0.0	0.0	0.0	0.0
Digital service integration	0.0	0.0	0.0	0.0	0.0	0.0
Ext. channels improvement	0.0	0.0	0.0	0.0	0.0	0.0
InfoNet refresh	0.0	0.0	0.0	0.0	1.5	1.5
Int. channels improvement	0.0	0.0	0.0	0.0	0.0	0.0
NG.com refresh	0.0	1.9	0.0	0.0	0.0	1.9
Stakeholder/internal apps.	0.5	0.0	0.0	0.0	0.0	0.5
Web minor works	0.0	0.0	0.0	0.0	0.0	0.0
Total	**0.5**	**1.9**	**0.0**	**0.0**	**1.5**	**3.9**

Figure 91 - Group capex investment in digital and web systems, 18/19 pricing, £ million, opex not shown.

Our digital communication channels sit at the heart of how we connect with stakeholders, customers, and colleagues. Our customers are increasingly dependent on mobile technology and modern digital communications encourage our employees to work effectively and add value. Our customers and stakeholders have told us they want us to develop improved communications channels that give access to self-serve data, enhancing the effectiveness of communication across the energy sector.

Efficiency benefits from investment in this space include:

- Less wasted time (quick to find or access things that matter).
- Targeted news and communications giving an effective internal voice.
- Reduction in the number of systems.
- Increased productivity (self-service, increasing ability to complete tasks).
- Employee awareness - access to expertise.
- Enables us to work faster, bringing alignment and visibility between departments.

7.9. Other core functions

Within business services there are other key services which have been grouped into ‘other core functions’. These are:

- Safety, Health and Sustainability
- Internal Audit
- Enterprise Risk Management
- Legal
- Systems for IT to manage the technology environment

Group investments of £7 million are required during the RIIO-2 period to refresh, sustain and/or implement capability and functionality for these core functions.

	2021/22	2022/23	2023/24	2024/25	2025/26	Group Total
Global travel mgt.	0.0	0.0	0.0	0.0	0.0	0.0
Identity and access mgt.	0.0	0.0	0.0	0.0	0.0	0.0
Safety incident mgt. and related SHE systems	0.4	0.8	0.3	0.2	0.2	1.8
Upgrade of UK IMS system	0.0	0.0	0.0	0.0	0.0	0.0
Employee digital workplace	0.0	0.0	0.0	0.0	0.0	0.0
RSA Archer upgrade	0.5	2.0	0.5	0.0	0.3	3.3
Analytics and visualisation	0.3	0.0	0.0	0.1	0.0	0.5
Investor relations web	0.0	0.0	0.0	0.0	0.0	0.0
IT provisioning and software licence asset mgt.	0.0	0.0	0.3	0.1	0.0	0.4
IT tools for planning and delivery	0.0	0.4	0.0	0.0	0.2	0.6
Agile development tooling	0.0	0.0	0.3	0.0	0.0	0.3
Boardvantage	0.0	0.0	0.0	0.0	0.0	0.0
Legal analytics and visualisation	0.0	0.0	0.0	0.0	0.0	0.0
Legal matter mgt. upgrade	0.0	0.0	0.0	0.0	0.0	0.0
Legal support systems	0.0	0.3	0.0	0.0	0.2	0.5
Corporate regulated minor works	0.0	0.0	0.0	0.0	0.0	0.0
Total	**1.2**	**3.5**	**1.3**	**0.4**	**0.8**	**7.2**

Figure 92 - Group capex investment in other systems, 18/19 pricing, £ million, opex not shown.

Safety is and always will be our number one priority – we will continue to invest in our incident management systems to ensure they remain fit for purpose and reflect the increasingly mobile nature of our workforce. We will also invest in increasing the capability of our health and sustainability systems with a number of initiatives, including safe driving, health dashboards and sustainability management.

We will maintain our investment in RSA Archer to provide an integrated governance risk and compliance platform connecting the first, second and third line of audit and assurance defence and consolidating all risk-related data onto one platform.

We will need to maintain our legal document management, contract automation and spend tracking platforms to enable the effective operation of our legal function.

In addition, maintaining and/or upgrading our IT for IT tooling (internal IT-enabling tools to manage services and projects) will be required to ensure we have effective and integrated platforms to support software and project delivery.

This will enable our IT organisation to effectively manage cost, vendors and contractual agreements in addition to providing cost and service transparency. This will reduce operating costs across the business, supporting the IT strategy for application rationalisation and minimisation.

7.10. Options

Finance

The following table describes the high-level options considered for this business theme. Other initiatives in this group, being relatively low-level individual investment lines, will go through a rigorous option phase during the sanctioning process.

Option	RIIO-2 TCO	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
Maintain only	**This option involves upgrades and minor change - continual improvements only**					
	GREEN	**GREEN**	**RED**	**RED**	**RED**	**Rejected**
	£15m	• The existing team could be reduced and deliver this option. • Losing team members would reduce future capability. • Staff retention likely to become a problem due to work profile.	• Will erode business productivity due to system configuration not reflecting business processes. • Inhibit ability to benefit from new capabilities in the future.	• Does not evolve business or allow it to adopt new capabilities in line with the industry standards and efficiency levels.	• Could result in manual offline process workarounds. • Limited ability to exploit efficiencies offered by new features and functions. • Governance and compliance will become more challenging.	
Maintain, enhance	**This option is to deploy upgrades, deliver business-driven functional changes and exploit new functions and features from software releases**					
	GREEN	**GREEN**	**GREEN**	**GREEN**	**GREEN**	**Recommended**

Option	RIIO-2 TCO	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
and evolve	£46.7m	• Solution Development Team in place. • Support model matured from RIIO-1 system deployment.	• Maximise return on investment from RIIO-1. • Support business pursuit of further efficiencies. • Supports continual integration with SaaS and third party systems.	• Aligns to continual improvement to allow business to reach their operational efficiency targets.	• Internal capability/expertise is required to ensure new functions and features are exploited in a cost-efficient way.	
Replace	**This option would see the S4 / ECC SAP replaced with a new ERP**					
	RED	**RED**	**RED**	**RED**	**RED**	**Rejected**
	c. £115m	• Would require significant FTE effort.	• Wasted sunk cost in S/4HANA during RIIO-1. • Potential to increase integration complexity with surrounding systems. • Alternatives may/may not cover the full scope of services required leading to proliferation of products/systems.	• No real advantage over-staying with SAP. Implementation costs will outweigh any potential commercial benefit.	• Financial write off of assets not fully depreciated. • Implications on integrated systems, such as procurement suites. • Risk of change to supplier who is not familiar with NG processes.	

Procurement

The following table describes the high-level options considered for the major investments for this business theme. Other initiatives in this group, being relatively low-level individual investment lines, will go through a rigorous options phase during the sanctioning process.

Option	RIIO-2 TCO	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
Maintain only	**This option involves upgrades and minor change continual improvements only**					
	AMBER	**GREEN**	**RED**	**AMBER**	**AMBER**	**Rejected**
	£3m	• A reduced existing team could deliver this option. • Losing team members would reduce capability to deliver in the future.	• Will erode productivity due to stagnating processes. • Inhibit ability to leverage new capabilities in the future.	• Allows for legal and mandatory changes to occur. • Does not evolve business or allow it to adopt new capabilities in line with the rest of the industry.	• Could result in manual offline process workarounds. • Limited ability to exploit new efficiencies offered by new features and functions.	
Maintain, enhance and evolve	**This option is to deploy upgrades, deliver business driven functional changes and exploit new functions and features from software releases**					
	GREEN	**GREEN**	**GREEN**	**GREEN**	**GREEN**	**Recommended**
	£8m	• Solution development team in place. • Support model matured from RIIO-1 system deployment.	• Maximise return on investment from RIIO-1. • Support business pursuit of further efficiencies.	• Aligns to continual improvement to allow business to reach their operational efficiency targets.	• Internal capability/expertise is required to ensure that new functions and features are exploited in a cost-efficient way.	

Option	RIIO-2 TCO	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
Replace	**This option would see the Coupa and SAP Ariba replaced with a competitive product.**					
	RED	**RED**	**RED**	**AMBER**	**RED**	**Rejected**
	£12m	• Would require significant FTE effort. • Need to reskill / replace team.	• Sunk cost in Coupa/Ariba during RIIO-1	• Minimal possibility of capability uplift as current solutions are already top quartile products.	• Premature investment in replacing existing application estate. • Risks inherent of a new supplier.	

HR and workforce systems

The following table describes the high-level options considered for the major investments for this business theme. Other initiatives in this group, being relatively low-level individual investment lines, will go through a rigorous options phase during the sanctioning process.

Option	RIIO-2 TCO	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
Maintain only	**This option involves renewal of software licenses at contract end and continued infrastructure provision but no changes to application stack or versions**					
	GREEN	**GREEN**	**RED**	**RED**	**RED**	**Rejected**
	£4m	• Reducing the existing team could deliver this option. • Losing team members would reduce capability to deliver in the future.	• Wouldn't meet corporate IT asset health policies. • Inhibit ability to utilise new capabilities in the future.	• No impact on improving efficiency • No impact on improving stakeholder experience	• Security vulnerabilities will not be addressed. • Legal / mandatory updates not possible. • Enhancements will be required to meet new regulations. • Vendor support.	
New Platform	**This option would see the SAP SuccessFactors functionality moved to a competitor platform following a competitive tendering process and a large-scale multi-year programme to migrate data and processes.**					
	RED	**RED**	**RED**	**RED**	**RED**	**Rejected**

Option	RIIO-2 TCO	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
	£13m	• Would require significant FTE effort. • Need to reskill / replace IT team. • Business disruption when replacing and adopting the new solution.	• Sunk cost in SAP SuccessFactors during RIIO-1.	• Any new solution would be evaluated to ensure it meets business needs.	• Creates need for complex integrations with surrounding SAP landscape.	
Maintain, enhance and evolve	**This is option involves maintaining the current landscape to an n-1 software level and ensuring the hosting footprint is in line with the wider hosting strategy**					
	GREEN	**GREEN**	**GREEN**	**GREEN**	**GREEN**	**Recommended**
	£9.4m	• Solution development team in place. • Support model matured from RIIO-	• Exploits RIIO-1 investment. • Maintains security compliance. • Maintains compatibility with wider on	• Minor capability improvements advance the efficiency of operations.	• Internal capability/expertise is required to ensure that new functions and features are exploited in a cost-efficient way.	

Option	RIIO-2 TCO	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
		1 system deployment.	premise and SaaS eco-systems.			

Digital and web applications

The following table describes the high-level options considered for the major investments for this business theme. Other initiatives in this group, being relatively low-level individual investment lines, will go through a rigorous options phase during the sanctioning process.

Option	RIIO-2 TCO	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
Maintain only	**This option involves renewal of software licenses at contract end and continued infrastructure provision but no changes to application stack or versions**					
	GREEN	**GREEN**	**RED**	**RED**	**RED**	**Rejected**
	£2m	• A reduced existing team could deliver this option. • Losing team members will reduce capability to deliver in the future.	• Many current solutions are sub optimal and highlighted by stakeholders as in need of improvement.	• No impact on improving efficiency. • No impact on improving stakeholder experience.	• Health of the current solutions will continue to deteriorate and lead to further inefficiencies in operations. • Mobile/web technologies will evolve rendering current system incompatible with user devices.	

Option	RIIO-2 TCO	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
New platform	**Replacement of all digital channels**					
	RED	**RED**	**RED**	**RED**	**RED**	**Rejected**
	£14m	• Employees stretched as also maintaining BAU processes. • New skills and capabilities needed to support investments. • Business operating model challenges ability to fully exploit new technology opportunities.	• Existing big platform investments lost but offer a wider consolidation or simplification of systems. • Alignment with business needs can be optimally met.	• Technology solutions are all fit for purpose. • Stakeholder needs fully accounted for.	• Wider change and downstream impacts adding complexity. • High complexity overall and changes needed to process, people and data to support new technology adoption could be overwhelming. • Difficult to achieve a valued return on investment.	
Maintain, enhance and evolve	**This option is to deploy upgrades, deliver business driven functional changes and exploit new functions and features from software releases**					
	GREEN	**GREEN**	**GREEN**	**GREEN**	**GREEN**	**Recommended**

Option	RIIO-2 TCO	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
	£3.9m	• Established skills and capabilities follow a gradual evolution supporting smaller incremental changes that are easier to deliver.	• Builds on existing strategic platforms maximising return on investment. • Existing core platforms can be extended and are not end of life. • Supporting systems can change to meet business needs.	• Allows for considered flex and change to meet stakeholder needs.	• Smaller incremental changes that are easier to deliver.	

Other Core Functions

This is a collection of investments relating to various areas of the business including:

- Safety, health and sustainability
- Internal audit
- Enterprise risk management
- Legal
- Systems for IT to manage the technology environment

Despite being relatively low-level individual investment lines, all initiatives in this group will go through a rigorous options phase during the sanctioning process. The largest investment line in the group is related to RSA Archer which is our integrated risk management platform used to monitor, identify, assess and decide on risk. Risk management is key to the ESO to ensure the security and stability of its critical national infrastructure therefore it is essential the system is maintained in line with advances in the wider industry to allow us to continue to manage the magnitude, velocity and complexity of today's existing and emerging risks.

7.11. Key assumptions, dependencies, and risks

Assumptions

- Key business capability requirements will remain generally unaltered.
- Scope of functions remains broadly in line with plan for transformation.
- Investments in technology remain aligned to current vendor roadmaps e.g. SaaS offerings and releases.
- Software versions maintained in line with corporate IT asset health policies.
- Volumetric data, such as number of users or number of transactions, remains largely unchanged as no financial provision for increases are made.

Dependencies

- Reliance on business transformation to align changes in process, culture and behaviours to support the use of new technology.
- Reliance on data enhancement strategy being developed in parallel with new systems and processes.
- Reliance upon supplier product development delivering against roadmaps.
- Interdependency where a fully integrated SAP landscape must be aligned with supplier enhancement roadmaps.
- The pace of technological progress is high and accelerating, we are dependent upon no significant changes to core technologies, contracts to deliver SaaS services, or ways of working that significantly impact our plans.

Risks

There is a risk that …	Mitigation
We incur cyber and security breaches.	Ensure systems are maintained to latest vendor released versions. Maintain a strong cyber capability within the National Grid group which regularly assesses the IT landscape for vulnerabilities
We incur cost to reimplement systems delivered in RIIO-1.	Ensure systems are maintained to latest vendor-released versions to avoid systems becoming obsolete and incurring more significant investment or replacement.
We incur financial and reputational penalties.	Maintain systems at the latest vendor-released versions to ensure patches cover any legal and legislative requirements.
We are unable to unlock new value.	Maintain systems at the latest vendor released versions to reduce the time to value in enabling task automation functionality that releases HR to focus on higher value activity.
We suffer controls and compliance failures.	Ensure both IT systems and business support teams supporting the GRC space are maintained.
We lose talent from the organisation.	Ensure a program of continual improvement is implemented to help retain talent and knowledge within the National Grid group and avoid a famine and feast mentality in application lifecycle management.
The efficiencies made in RIIO-1 are eroded.	Ensure the IT systems evolve with the business requirements over time to prevent the formulation of offline processes.
We are unable to fully digitalise the support functions.	Maintain a strong enterprise architecture capability to ensure the strategy is adopted and matured in line with evolving aspirations.
Vendors release exceptional updates (re-platformed or re-architected solutions) which require major migration activity to continue using the product.	Funding may need to be diverted from enhancements that maintain or improve business efficiency to fund an exceptional upgrade activity.
A failure to keep the whole ecosystem current could seriously impact the value chain due to interconnected nature of systems.	Ensure all applications in the estate are maintained in a consistent manner. For systems on the perimeter, ensure they are integrated through centralised API management rather than point-to-point.

7.12. Conclusion

As a group, we will invest £75 million (£12 million for ESO) to maintain and evolve the IT systems delivering business services.

This carefully considered and well-balanced direction will ensure we continue to unlock efficiencies delivered in RIIO-1. These investments align with our wider IT strategy and support the ESO in becoming a digital enterprise.

Our RIIO-1 investment strategy has met the immediate needs of the businesses and put in place platforms for continued growth. Wherever possible, we have used these technologies without customisation so we can maximise industry standard platforms as they continue to be evolved by the manufacturers.

Our strategy for RIIO-2 is to keep platforms current through incremental investment, avoiding the need for major system replacements with associated cost and risk. New functionality will further increase our efficiency and maintain a secure and controlled eco-system. This strategy strengthens our data management capability by adding advanced analytics that come with core platforms helping minimise the movement of data between systems.

This investment supports the delivery of 1.1 per cent year-on-year efficiency improvements across the support functions, which represents almost three times the current UK trend for productivity improvement, through adoption of new capabilities. Without the ongoing maintenance of our systems, we will not be able to maintain compliance with relevant legislation and regulations. The investments made in RIIO-1 will become outdated and inefficient, exposing our systems and data to an increased cyber risk and operational failure. The investment has been independently benchmarked by Gartner to be within our peer group range.

8. Shared investments: end user computing

8.1. Executive summary

End user computing comprises end user devices, printing, and the new digital workplace, to provide fast, frictionless, end user services.

End user computing provides all employees, contractors and partners with a reliable, secure and high-performing work environment that supports the ESO business. At its heart is the use of technology to transform the end user experience, protecting productivity and efficiency by supporting the introduction of new capabilities. It focuses on providing IT support that is convenient, fast and frictionless.

These services bring significant improvements in productivity and a greater retention of skilled resources. This supports the 1.1 per cent year-on-year efficiency improvement target in National Grid group performance which results in cost reductions for consumers.

An investment by the group of £24 million (£4 million allocation for ESO) across the RIIO-2 period is required to refresh and enhance assets that deliver these services.

	2021/22	2022/23	2023/24	2024/25	2025/26	Group Total
Customer experience	0.0	0.0	0.0	0.0	0.0	0.0
Emerging technologies	0.5	0.5	0.5	0.5	0.5	2.5
End user computing	5.0	4.0	4.5	4.0	4.0	21.5
Unified communications and collaboration	0.0	0.0	0.0	0.0	0.0	0.0
Total	**5.5**	**4.5**	**5.0**	**4.5**	**4.5**	**24.0**

Figure 93 - Group capex investment in end user computing, 18/19 pricing, £ million, opex not shown.

The asset policies that underpin these investments and the level of investment required were compared with Gartner, a recognised expert in technology benchmarking. Gartner[7] indicates the asset health policies are in line with industry practice, and the value of investment is within the benchmark range.

8.2. Introduction

The National Grid group is undergoing a technological and digital transformation, driven by our vision of exceeding the expectations of our customers, stakeholders, and

[7] Use These Recommended Life Spans to Guide Mobile, PC and Other Device Replacement Strategies, Gartner Research, ID G00350411

communities in a rapidly changing and increasingly competitive energy landscape. Technology plays a vital role, enabling us to optimise operational performance, identify and realise opportunities to grow, and be better equipped for the future.

A key focus for the IT function is improving the technology experience for our employees, contractors and partners. We want their daily use of our technology to make them engaged, agile, secure, and productive. A study by Forrester Research of Microsoft Office 365 collaboration software showed savings of 1.81 hours per week per worker and a 12.75 per cent reduction in decision-making time, bringing improved customer response.[8]

The end user computing investment covers three main themes:

- End user devices – ongoing programme to maintain performance of end user devices and associated services.
- Unified communication and collaboration – ongoing programme to support efficient employee interactions across multiple platforms.
- Emerging technologies – programme of work to analyse and implement as appropriate disruptive/new technologies.

8.3. Background information

Delivery model

The National Grid group has chosen to source selected elements of IT from external companies who can bring economies of scale, best in class services, and innovation. We have recently completed a series of market events and awarded contracts to several global IT vendors to deliver managed workplace services, along with application maintenance and development.

These contracts, and in particular the managed workplace services contract, have been scoped to deliver these investments. For example, the managed workplace services contract includes a three-year refresh of devices.

Workforce

The Y and Z generations, who have grown up in a connected, collaborative and mobile world, and will account for over half of the workforce before the end of the RIIO-2 period. This change in workforce balance will redefine corporate culture and expectations of the workplace. Our systems will need to support flexible working and a more open and social approach to collaboration that is increasingly automated, intelligent and very data centric.

8.4. Overview of investments

Modern workplace end user service

This investment supports the ongoing maintenance of end user services, ensuring performance continues to support productivity and meets the needs of business operations. Investments are:

Device refresh

During the RIIO-1 period, devices have been replaced based on service failure, on average after four to five years. During the later stages of RIIO-1, this approach has proved to be incompatible with the move to cloud services and was leading to a loss of

[8] The Total Economic Impact™ Of Microsoft 365 Teamwork Solutions, Forrester Research, 2018

productivity for users of devices four years and older. Examples of this are extended log in times and poor performance with shared documents. In addition, employee survey feedback highlighted that employees found technology to be a blocker to doing their jobs effectively.

To ensure a managed approach to maintain appropriate performance levels,the asset refresh policy has been updated to replace devices every three years (3,000 devices per year) as a continuous program of work (rather than discrete projects as previously). This has been benchmarked by Gartner Research[9] as in line with industry best practice. Key drivers of this approach are:

- Having up-to-date infrastructure is an essential prerequisite for maintaining the right levels of security for a company running critical national infrastructure.
- Old equipment consumes increasing resources and budget with diminishing return.
- Inflexible and outdated technology makes it difficult to support new business demands and the digital workplace.
- End-users are equipped with effective IT tools to do their jobs efficiently.

Services upgrade and refresh/living with cloud

An ongoing programme to support refreshes and upgrades of core services, for example Microsoft Office 365 and Windows 10 are critical to performance. As more cloud-based services dictate the pace of change, we will need new capability to manage updates and refreshes. This includes services to manage the change as well as reducing complexity in estate to reduce impact of changes. For example, Microsoft has released 343 updates to Office 365 in the last 12 months with a further 330 planned for the next 12 months. The inability to evaluate future changes will at best prevent efficiency improvements and at worse disrupt services to end users. Examples of recent changes include:

- Secure biometric login of Windows 10 requires appropriate hardware support outside our device estate. With the right hardware these features provide a more secure and efficient log in.[10]
- Microsoft has added a new mobile messaging service (Kaizala) to Office 365. Potentially this application can provide significant safety and productivity improvements through the digitalisation of field process, such as recording job progress or providing remote expert support.
- Microsoft has announced that Skype for Business (the current National Grid group messaging tool) will be retired in June 2021 and the functionality moved to Teams which launched in 2017. The impact of this needs to be assessed and users ultimately migrated to Teams by 2021

Security and management of devices (EMM)

As demand for a more diverse selection of devices grows and cloud services evolve, the management of these devices and services becomes more complex, requiring new tools and services. An enterprise mobility management solution will be deployed to manage tablets, mobiles and laptops on a common platform.

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[9] Use These Recommended Life Spans to Guide Mobile, PC and Other Device Replacement Strategies, Gartner Research, ID G00350411

[10] https://docs.microsoft.com/en-us/windows/security/identity-protection/hello-for-business/hello-why-pin-is-better-than-password

Unified communications and collaboration

Unified communications and collaboration tools support the environmental objectives and improve productivity by improving employees' ability to collaborate remotely and reduce travel.

Fixed video and telepresence conference units

The National Grid group supports 86 videoconference units. These have a lifespan of five years and we aim to replace each device over the RIIO-2 period and increase the number to 110. We also have two telepresence units in the UK which will need refreshing in year three of RIIO-2.

SharePoint refresh

Existing SharePoint collaboration platforms are end of life and without supplier support, leading to increased support costs and security risks. These platforms need to be migrated to the current collaboration Office 365.

Innovation/emerging technologies

With the rapid development of technology services such as augmented reality, automation, and intelligent algorithms, opportunities will emerge through the RIIO-2 period that we can use to improve productivity and make efficiency savings.

8.5. Options

Options for these investments can be themed around three areas:

Hardware Refresh

In assessing the options detailed in the table below, we have listened to users through our employee engagement surveys and feedback from direct interactions with IT, analysed failure trends and performance data such as log in times. This all shows user productivity is being impacted by old assets and inappropriate services. The preferred option is a three-year refresh cycle. Benchmarking was undertaken with Gartner Research to understand factors influencing refresh (reliability and suitability) as well as typical policies in other sectors.

Service health

These investments allow changes of modern IT cloud services. The options are either to invest to maintain the service health or do nothing. An assessment of each change would be undertaken to determine the extent of service degradation that results from not implementing. Only changes having a material impact would be undertaken.

Efficiency Improvement

These investments allow for services to exploit new capability of modern IT cloud services. The options are either to invest or do nothing. Using cloud services improves productivity and delivers efficiency savings to be shared with the consumer.

Table of options considered

Option	Total Cost of Ownership	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
Do nothing/ refresh over five years.	**GREEN** • Minimal outlay	**RED** • Aged device estate already causing significant disruption to business	**RED** • Devices unable to support new technology. • Hinders ability to exploit value from new technology	**RED** • Does not address end user experience and performance issues.	**RED** • The rapid evolution of new technology increasingly makes older environments obsolete and unsupported. • This poses a risk to cybersecurity, resilience and efficiency.	**Rejected**
Refresh over three years.	**GREEN** • Ensures best value between staying modern while leveraging asset. • In line with Gartner mainstream recommendation.	**GREEN** • New managed workspace services (MWS) contract structured to give rolling upgrade of devices.	**GREEN** • Devices replaced every three years in line with policy. • Devices are maintained to current operating systems,	**GREEN** • Ensures improvement to end user experience and performance. • Supports introduction of new	**GREEN** • Security reliability and performance risks mitigated.	**Recommended**

Option	Total Cost of Ownership	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
			receive ongoing security patches and deliver good performance.	technologies.		
Refresh over four years.	**AMBER** • While within Gartner two to four-year recommendation, would require higher specification devices with higher initial cost.	**GREEN** • New MWS contract structured to give rolling upgrade of devices.	**GREEN** • All devices are maintained to current operating systems, receive ongoing security patches and deliver reasonable performance.	**GREEN** • Ensures improvement to end user experience and performance. • Supports introduction of new technologies.	**GREEN** • Security reliability and performance risks mitigated.	**Rejected**

8.6. Key assumptions, dependencies and risks

Risk driver	Assumptions	Impact
Most of the investment is driven by device refresh which is dependent on user numbers and device-to-user ratio.	User numbers remain broadly flat.	A significant change in device numbers would result in a corresponding change in investment.
Most of the investment is driven by device refresh. Technology hardware is typically priced in US dollars	It is assumed that GBP:USD currency rates remain stable and vendors do not realign to UK pricing.	A significant change in exchange rate due political events may impact hardware purchase costs (as seen during RIIO-1).
RIIO-2 covers a long time period from a technology development perspective. New technologies or methods of working may change investment profile.	Current planned solutions will not change unless there is a financial/efficiency benefit.	Split between opex and capex may change but totex will remain same or be reduced.

8.7. Conclusion

A modern workplace will deliver a reliable, secure and high-performing modern workspace for the excellent user experience and a work environment our users and stakeholders tell us they needed to operate effectively. It will also efficiently support the National Grid group and ESO business operations by maintaining high-levels of productivity.

9. Shared investments: hosting

9.1. Executive summary

Hosting covers several technologies such as storage and computing. These may be hosted in a physical data centre owned and operated by the National Grid group or by a third party and may be hosted remotely in either public or private cloud. These environments are accessed by a network connection from the National Grid group.

At the beginning of the RIIO-1 period, we responded to the challenge from Ofgem deliver efficiencies by investing to extend the asset life of much of the hosting technology, reducing capital investment in replacements and generating savings for the consumer. As the RIIO-1 period progresses it has become apparent through employee feedback and performance data that the older technologies in our estate have become a serious blocker to performance and productivity. The escalating threat of a cyber attack on our IT systems caused us to revisit how we can proactively monitor and prevent cyber threats and ensure IT systems continue to underpin the productivity of our workforce.

In 2018, we re-examined our asset health policies governing all areas of IT technology refresh, leading to a revision of those policies which has been externally benchmarked by Gartner, a leading authority on IT benchmarks. The revised policies led to increased investment in IT infrastructure investment beyond our RIIO-1 allowances.

We propose to invest £106 million as a group (£33 million allocation for ESO) over the RIIO-2 period.

	2021/22	2022/23	2023/24	2024/25	2025/26	Group Total
Cloud and hosting	25.4	4.5	5.0	10.0	2.0	46.9
CNI infrastructure	4.3	3.4	3.5	2.0	2.0	15.2
Platforms	15.5	14.3	6.5	4.5	3.5	44.2
Total	**45.2**	**22.2**	**15.0**	**16.5**	**7.5**	**106.3**

Figure 94 - Group capex investment in hosting, 18/19 pricing, £ million, opex not shown.

The investments proposed in the RIIO-2 period will continue to maintain the asset health of our IT estate in line with our policies.

One of the key learnings from the RIIO-1 period is that the perceived savings from extending core IT asset life can be a false economy in the longer term. The impact on productivity, efficiency and customer satisfaction is felt across the whole organisation when IT infrastructure impedes new operational technology or software updates. Investment in new applications and tooling can only deliver benefits if the underlying infrastructure is effective.

To support the business ambition and deliver against the expectations of our customers and stakeholders, we need to complete the programme of infrastructure modernisation started during RIIO-1. We have evaluated a range of options to meet our hosting requirements and concluded that a hybrid cloud solution is the most effective approach. We will invest during the RIIO-2 period to modernise our hosting infrastructure, enabling us to continue to deliver a safe and reliable network and services to our customers and stakeholders.

9.2. Introduction

Hosting covers the computing and storage environments which run our applications, in the same way your desktop or laptop computer has an operating system (Windows 10), storage (the hard drive you store your data on), and contain the CPU and RAM that process instructions. These component parts are contained in a case which provides the power supply and cooling. On a larger scale this is a data centre.

Effective hosting environments are vital to a large scale business such as the National Grid group, providing the infrastructure on which data is stored manipulated and processed. Operational processes and business decisions are based on the organisation, and presentation of data. Poorly performing or unreliable hosting infrastructure has a significant impact on overall organisational performance.

The following terms describe different cloud technologies:

Public cloud

These are computing services offered by third party providers over the public internet. Customers typically pay only per usage for the CPU cycles, storage, or bandwidth they consume; pre-buying is an alternative option. Examples include Microsoft Azure, AWS, and Google.

Public cloud providers buy, manage, and maintain the infrastructure. They have virtually infinite scale customers. The public cloud is secure if the provider uses proper security methods.

Private cloud

These are computing services offered primarily over a private internal network for a single company. They offer businesses many of the benefits of a public cloud - self-service, some scalability, and some flexibility - with additional control and customisation. Security may be better as it uses company firewalls and internal hosting to ensure operations and sensitive data are not accessible to third party providers. Internal IT departments are responsible for the cost and accountability of managing this estate and require the same staffing, management, and maintenance expenses as traditional data centre ownership.

With both cloud types, there are different ways to deliver technology requirements. Infrastructure as a service (IaaS) include infrastructure resources such as computing, network, and storage as a service. Platform as a service (PaaS) are simple cloud-based applications as well as sophisticated enterprise applications.

Private clouds can be combined with public clouds to create a hybrid, allowing a business to take advantage of ‘cloud bursting’ to free up more space and scale services to the public cloud when demand increases.

We submitted proposals for the RIIO-1 period including allowances for maintaining the asset health of IT infrastructure. In setting allowances below the requested level, the regulator challenged us to deliver IT infrastructure services more efficiently. We responded to this challenge by extending the technical lives of our IT infrastructure assets, accepting higher levels of risk while maintaining performance and availability.

As we continued through RIIO-1, our employees fed back that our IT was becoming a significant blocker to their effectiveness. Along with the escalating threat of cyber attack it casued us to review how we monitor and prevent cyber threats and ensure IT continued to underpin the productivity of our workforce.

With a significant proportion of our IT hosting assets at or beyond end of life, the growing cyber threat and the increasing risk of failure forced us to re-examine the asset health policies. This has led to increased spending on IT hosting technologies, mitigating risk, driving improved operational performance and reducing operating costs.

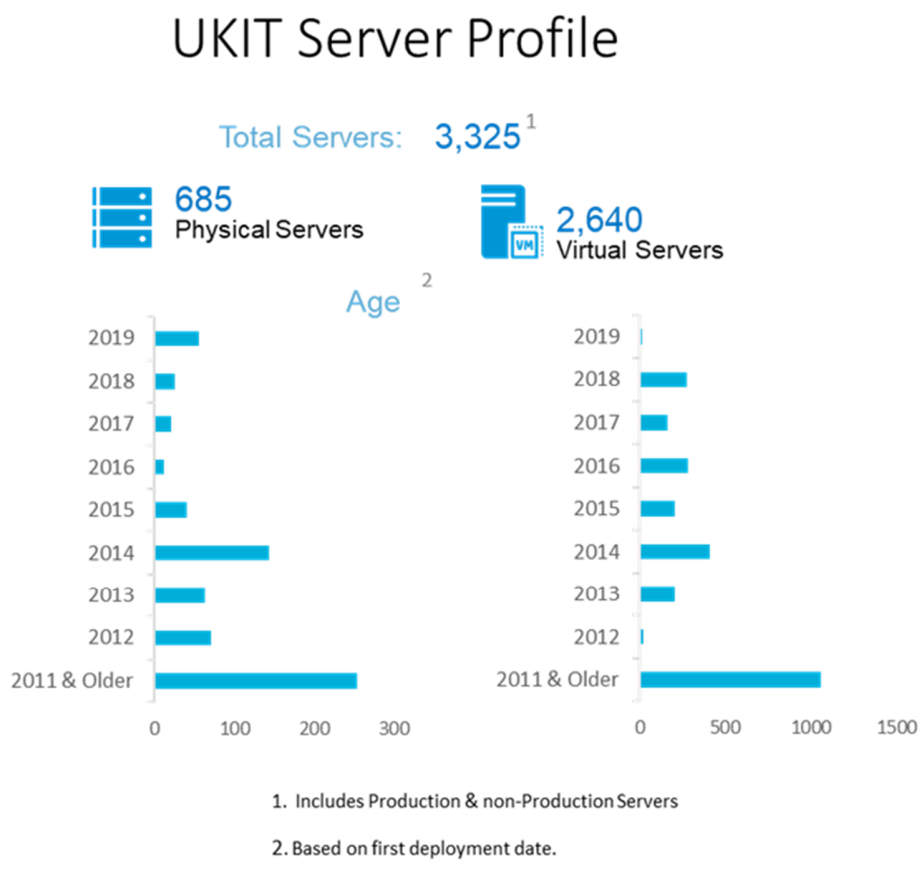

Figure 95 – UK server ages

Our estate consists of internally-hosted and managed physical assets, virtual assets hosted either internally or by third party, and public cloud.

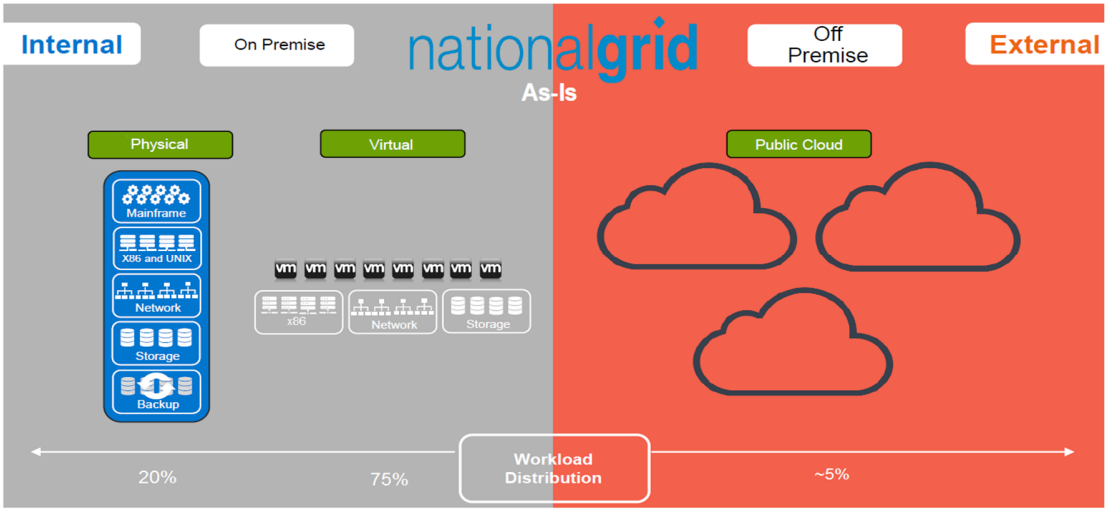

Figure 96 – Current workload distribution across cloud offerings

The energy sector's move to zero carbon is bringing a period of unprecedented change. The National Grid group is undergoing a technological and digital transformation, driven by our vision of meeting the needs of customers, stakeholders, and communities in a rapidly changing, and increasingly competitive energy landscape. IT plays a vital role in delivering world class operational performance, bringing opportunities to transform to meet customer and stakeholder expectation in the energy world of the future.

Our IT solutions are a vital part of the ecosystem that delivers safe, secure and reliable energy networks. It delivers the innovations our customers need, allows us to react to regulatory change and facilitates the efficient and effective operations of the National Grid group. Without investment to modernise and maintain fit for purpose IT solutions, our ambition to be at the heart of the new energy world will be severely compromised.

The full range of solutions for operational platforms, from energy balancing and SCADA platforms, to analytical modelling such as digital twin technology are all dependent on a modern high-performance operating environment.

Our stakeholders and customers have told us they want safe, secure and reliable networks, efficient energy market operations and greater transparency of data. Above all, they want to be protected from external threat. Delivering these expectations is dependent on IT solutions.

To make our transmission networks ever more efficient, we are proposing continued investment in condition-based monitoring and analytics for its transmission assets. This generates large volumes of data and requires significant computing power.

To support our security teams in protecting the National Grid group and the networks and markets it operates in, it is vital that our core IT assets are fully supported, patched to protect from vulnerabilities and monitored by our cyber security technologies. Failure to complete the modernisation work on our infrastructure started in the RIIO-1 period would compromise sercurity and performance and limit our capability to provide a high-quality service to our customers and stakeholders.

9.3. Options

We have identified four options for the management of core IT assets as we move towards the RIIO-2 period.

- Continue with the approach inherited from RIIO-1, making minimal investments to replace defective devices and only providing new assets to meet additional demand (minimal investment).
- Move applications and services to public cloud providers and adopt a cloud only strategy for new services.
- Exclusively adopt private cloud.
- Develop our strategy by optimising infrastructure and develop our hybrid and cloud capabilities for connectivity and integration.

Evaluation criteria

The following options will be evaluated based on cost, strategic and technical fit. Appropriate weighting will be applied to ensure that technical fit (ensuring the chosen solution meets the technical requirements of the application set to be hosted), strategic fit (solutions align with the strategic direction for IT technology, ensuring effective and efficient integration with the remaining IT landscape), and cost (ensuring value for money).

Option to continue with RIIO-1 approach

This would minimise investment in the short term by continuing to extend existing assets. It would also represent the maximum risk as IT assets have a typical design life of three to seven years. A significant proportion of the core IT estate is beyond end of life, increasing the risk of failure. More importantly it indicates these devices are unlikely to meet all functionality requirements effectively.

Old devices that are no longer supported with updates or leave vulnerabilities unpatched, can constrain the entire estate due to compatibility issues between updated and legacy software revisions. Failure to access the full functionality of modernised fully patched and updated IT hardware compromises the effectiveness of the entire IT system.

Figure 97 – Equipment condition and relationship to failure over time demonstrates the changing definition of infrastructure failure. It is no longer the point at which a device fails to operate, but is the point at which a device no longer meets the functionality requirement. This may be as a result of demand for increased performance or additional features. The time to implement replacement infrastructure is before the functionality or performance characteristics impact the effective business operation.

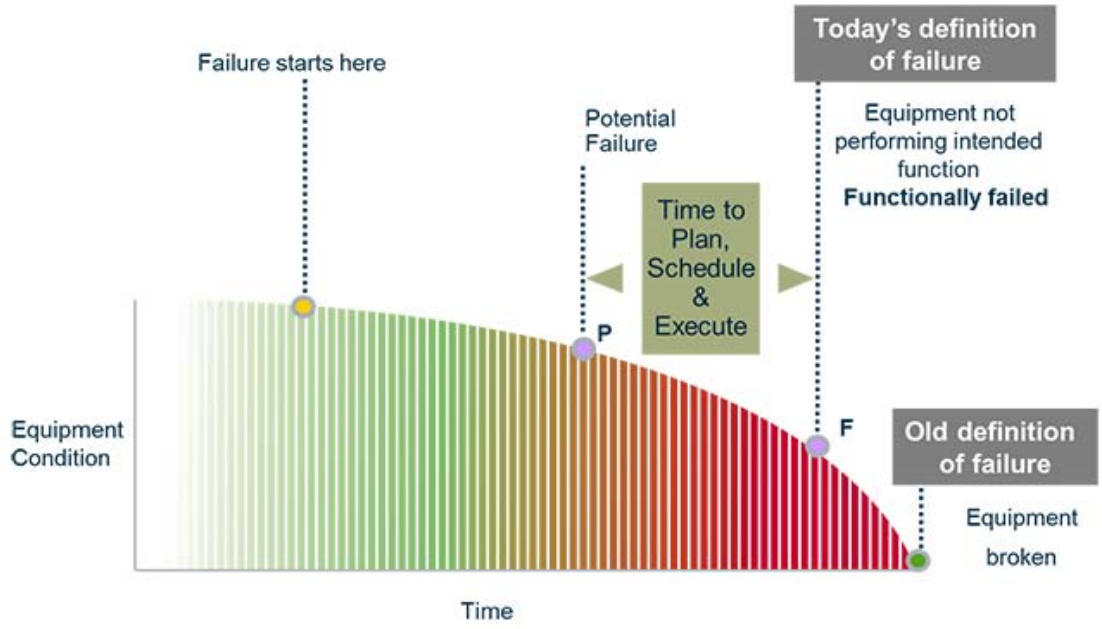

Figure 97 – Equipment condition and relationship to failure over time

Option to outsource IT infrastructure

The opportunity to outsource IT Infrastructure to public cloud may seem like a good idea with compelling benefits. However, the real cost of handing over control of IT infrastructure to external providers may prove to be more than the potential benefits.

To move all application hosting to a public cloud would bring potential issues with data security, ownership and performance. From the security perspective, some of our data is sensitive and would require extra consideration before a public cloud solution could be approved. Beyond the initial security consideration, some sensitive data may also have sovereignty compliance requirements that need careful management. Geopolitical restriction on data hosting becomes much more difficult to verify, making regulatory compliance a complex task.

The complex real-time applications we use to manage energy markets and networks place high demands on operational performance, with specific configuration requirements not delievered by the one size fits all, multi-tenancy public cloud environments, where control is ceded to the hosting provider, often requiring all users to maintain their estate fully patched and at latest revisions of operating systems. The level of testing to approve software updates before migration of critical systems may prove impossible within the cloud provider's time frames, but with the adoption of public cloud, the IT function loses direct control of this timetable, potentially causing critical infrastructure applications to be migrated to untested environments.

Financial forecasting and control of operating costs becomes increasingly complex, with many cloud models adopting a pay as you go model, where a detailed understanding of the likely volumes of data moving to and from the cloud becomes critical.

Option to adopt an exclusive private cloud

Adoption of private cloud brings many advantages over traditional physical hosting in terms of automation and operation.

To completely ignore the potential benefits of public cloud would represent a serious dereliction of our duty to the consumer. There are without doubt scenarios where hosting in the public cloud represents the best solution in terms of both cost and operational performance. Examples of this are in the growing range of solutions provided on a SaaS basis, where the software vendor supplies the solution on a subscription-based model, hosting the application on its infrastructure. These solutions are hosted on platforms optimised to the specific application requirements, updated by the product vendor to make sure benefits are realised as soon as possible.

Future requirements

Considering customer and stakeholder feedback, the operational requirements of the applications, and the requirements to modernise our estate, we have concluded that no single solution will meet all requirements.

The most effective solution is likely to be a hybrid solution, including SaaS for many commodity applications, such as ERP and CRM platforms, along with public and private cloud solutions.

Subscription-based software as a service SaaS solutions are becoming ubiquitous in many sectors, including ERP and CRM systems. This approach to common business applications brings many advantages, with the hosting environment optimised to the application to deliver good application performance. Routine software updates to both the hosting environment and the applications are tested and applied as part of the subscription.

Public cloud, while not appropriate for all applications, will retain a significant role in meeting our future requirements. Specific criteria will determine its suitability to meet security, cost, and performance objectives.

The investment in data centre technologies as part of the strategic CNI programme have created capacity for private cloud hosting. New technology, such as super and hyper-convergence, are shrinking the equipment power and cooling requirements, making on premise private cloud solutions more viable. Hyper-convergence enables scaling of computing and storage capacity and reduces reliance on separate network and storage resources because the traditional hardware infrastructure elements are software defined.

We have started a tender process to select the most suitable hosting provider based on our requirements and vision for our hybrid cloud future. We will award a contract in the current regulatory period that will be due for renewal within RIIO-2. We will be constantly assessing the market to ensure that our chosen hybrid strategy is optimal and taking full advantage of developments in the market and will adjust our strategy and criteria as needed. Closely aligning on and off premise architecture will also give us the flexibility to adjust and tender for other services if needed.

Target end state for preferred option

We will use agents to understand the current estate and interactions between systems to inform our actions. There will be a progressive migration of services to their optimum hosting

model. Starting in RIIO-1, these migrations will be aligned to major change programmes to avoid unnecessary disruption and cost. Figure 98 below shows how workloads are planned across the hosting models through the RIIO-2 regulatory period.

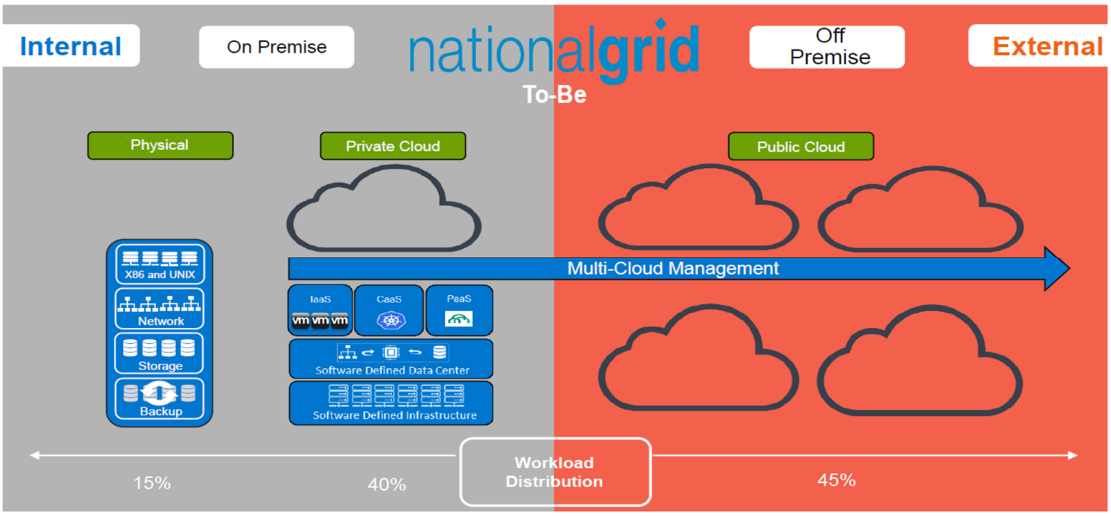

Figure 98 – Future distribution workload across cloud offerings

The hosting environment will need all complementary aspects of networking and security and will be optimised for our current applications. We will continually optimise our infrastructure requirements through:

- Application rationalisation and decommissioning coupled with data archiving and removal (in line with legal policies).
- Use of SaaS where available as a public cloud option, where our processes are sufficiently standardised can be delivered cost-effectively by SaaS to business users.
- Modernise our applications with solutions which recognise newer infrastructure technologies and associated cost of storage and computing infrastructure.
- Dynamic provisioning and consumption management to ensure only the resources required are used at any moment in time. This will include further flexibility to meet normal and peak workload demands.

Table of options considered

Option	Total Cost of ownership	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
Do nothing	**RED**	**GREEN**	**RED**	**RED**	**RED**	**Rejected**
	• High contract and support costs are expected if contract renewal were optioned.	• Use existing skills and resources. • Current Contract with DXC expires in 2021.	• Unable to use leading industry solutions and ability to change and innovate severely impacted.	• Does not address customer experience and resilience.	• Costs to host and manage would increase significantly. • High risk to service due to end of life hardware and software.	
Fully outsource (SaaS & Public cloud)	**RED**	**GREEN**	**GREEN**	**GREEN**	**RED**	**Rejected**
	• Highest cost	• External companies bring economies of scale, best in class services and innovation.	• Minimal effort to run and maintain systems. • Ability to use leading edge services for rapid change and innovation.	• Addresses customer experience, capacity and resilience requirements.	• Costs would increase and be difficult to manage. • Challenges with CNI workloads and alignment	
	GREEN	**RED**	**RED**	**GREEN**	**RED**	

Option	Total Cost of ownership	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
Fully insource (Private cloud)	• Higher costs of insourcing, training and operations.	• Difficult to acquire skills to build the environment. • Time and resource requirements considerable for a full private cloud build.	• Limits ability to use leading industry solutions. • Ability to change and innovate severely impacted.	• Addresses the resilience problems but will have limitations in meeting customer needs.	• Ability to acquire skills and build environments a major concern. • Being able to provide the required level of resilience and capacity.	**Rejected**
Mature Hybrid (preferred option)	**GREEN** • Best cost profile.	**GREEN** • Repurpose existing resource for new on-premise environments. • Cloud services where appropriate using cloud vendors.	**GREEN** • Enables the optimum balance of on-premise and commodity services.	**GREEN** • Addresses customer experience and resilience requirements.	**RED** • Suboptimal blend of cloud services • On-premise increases costs.	**Recommended**

9.4. Detailed analysis and cost/benefit analysis

A typical cloud strategy looks at people, process, information and technology across applications, client services and infrastructure services. Implementation usually occurs in three phases: modernisation, optimisation and transformation.

We are continuing to develop our IT investment submission, including a full cost benefit analysis. To ensure the level of investment for our recommended option is correct, we have extensively market tested it in line with industry best practice, referring to Gartner, a recognised expert in IT benchmarking. Gartner indicates our asset health policies are in line with industry practice, and the value of investment is within the benchmark range.Key benefits of our chosen strategy include:

- Ability to get the most of market investment in commoditised cloud services.
- Improved resilience from public cloud through enhanced models available from cloud providers, for private cloud from standardised hardware and availability of processes and technologies.
- Enhanced flexibility for workload, supporting digital initiatives.
- Cost avoidance through automation enabling us to absorb new workloads and contain costs in provisioning and decommissioning.
- Improved protection of the energy network through consistency and vendor best practice to reduce cyber and technology risk.
- Financial and non-financial benefits from improvements in standards, policies, and cost transparency from chargeback for better informed technology decisions.

To fully realise the benefits, we will need to move from expensive platforms to commodity hardware, for example moving from AIX onto Linux.This could take three to five years as this would be tied to other application roadmap events (refresh or replacement). Given the current level of technology and market maturity, the National Grid group currently views public cloud as not appropriate for strictly confidential and CNI data. This may change as cloud technology and security improve. Where possible we will use cloud hosting to harness scale and availability for IT services.

9.5. Key assumptions, dependencies, and risks

Assumptions

A critical component of a cloud strategy is taking a software-defined approach, the following details key assumptions:

- Computing resources should always be deployed as virtual machines, using a common hyper-visor.
- Computing and storage resources should be hosted on hyper-converged infrastructure (HCI) and all storage software defined.
- Where possible, network resources should also be deployed as software defined in a zero-trust model. This will allow greater flexibility, control and security when connecting public and private clouds.
- There should be a control plane to manage the full lifecycle of workloads, as well as an API layer to shift the consumption of hardware as software.
- Resources should be consumed as services.

Risks

We have also identified several risks in the table below that require mitigation plans to ensure the successful delivery of our commitments in the RIIO-2 regulatory period

There is a risk that …	Mitigation
Suppliers will not be able to deliver the services at the price agreed.	Extensive procurement process and analysis gives confidence that suppliers have a proven track record and can deliver value.
Strategy will not be executed optimally due to us not having the key skills to define new patterns, introducing additional risk of having to redesign at additional cost.	The selection and transition of services is being undertaken by employees who will implement and maintain these services. We will also supplement resource with contractors and partners. Key decisions will be reviewed by our central architecture review board and delivery teams.
The age of our current estate may make migrations challenging or unachievable. This may force application modernisation or other solutions.	Agent-based assessments and application estate assessment is being undertaken to better anticipate any risks and limitations.
New services are not available in time to exit from existing contracts.	Work has already begun to prepare for new hosting models and contract exit. We are regularly reviewing use and capacity.
There is a lack of automation in provisioning. The continued use of old ways of working are not designed for rapid scaling, resulting in not being able to react to future project requirements.	We are implementing a new operating model to focus on automation, update processes and ways of working, and bringing in key skills to meet future demand.
We don't have the capability to host legacy technologies.	Provision will be made in new contracts to allow for legacy systems.

Dependencies

To implement the proposed hosting solution and deliver efficiencies, it is vital also to implement the enterprise networks modernisation. Without modernised network capabilities, it will not be possible to migrate applications and platforms to public cloud or SaaS in the proposed volumes.

9.6. Conclusion

To identify the requirements for hosting we have assessed and understood our current and longer-term requirements, examined the market and tested our approach commercially and technically. We have listened extensively to our users and stakeholders, developing a strategy to provide effective, fit for purpose and efficient hosting services.

Our strategy is to continue to mature our hybrid cloud model. We started this journey prior to RIIO-2, building several key services on the Azure cloud platform and begun a proposal to re-contract our main hosting services. We have revised our strategy, reviewed and reinforced our

policies and governance bodies to assess workloads for optimum deployment, and created a cloud framework to guide execution.

We are building the architecture to enable our hybrid strategy, including connectivity and integration, and will architect services to build in flexibility for future change. Implementation of modern, secure and efficient hosting services enables us to operate a safe and reliable network and meet the expectations of our customers and stakeholders.

The combination of modernised hosting and network services underpin our strategy to deliver up to date, effective and efficient services enabling the National Grid group entities to operate efficiently.

10. Shared investments: IT operations and tooling

10.1. Executive Summary

Our IT operations have limited visibility of real user experience, we lack real-time data on end-to-end application performance, topological dependencies, and financial information. This makes application maintenance labour intensive and inefficient. Resources are assigned to manual operational effort with limited return. We do not currently design for automation first, so an incremental approach will miss the opportunities afforded by end-to-end monitoring and intelligent operations management tools.

We propose to invest £23 million as a group (£4 million allocation for ESO) over the RIIO-2 period.

	2021/22	2022/23	2023/24	2024/25	2025/26	Group Total
Cost analytics and transparency	3.0	0.0	0.0	0.0	0.0	3.0
Digital IT operations	5.0	3.0	2.0	2.0	2.0	14.0
Discovery tooling	2.0	1.0	0.0	0.0	0.0	3.0
Disaster recovery capabilities	3.0	0.0	0.0	0.0	0.0	3.0
Total	**13.0**	**4.0**	**2.0**	**2.0**	**2.0**	**23.0**

Figure 99 - Group capex investment in hosting, 18/19 pricing, £ million, opex not shown.

This investment will address these concerns over the RIIO-2 period. Automation will enable us to balance efficiency with the need for rapid change as we invest in the people, tools and processes needed to manage IT optimally. Gartner 2019 IT predicts cited IT automation as driving many benefits around efficiency, addressing talent shortages and enabling the delivery of data.

To ensure we maximise these benefits, we will focused on:

- Establishing transparency of IT cost across the business to enable accurate decision-making.
- Investing in tools, automation and process efficiency so that the IT estate can be managed as efficiently as possible across planning, build, provision and maintenance.
- Investing in the consolidation and automation of the network operations centre to ensure optimised network operations.

Bespoke IT solutions are designed to be deployed and operate without manual intervention. Commodity software platforms (e.g. Office 365) require radically different support models to bespoke solutions.

The implementation timeline for the automation of IT operations in RIIO-2 is as follows.

- Short term (0-24 months) – introduce performance monitoring, create rich performance data and prove the automation concept.
- Medium term (two-five years) – repurpose applications to fit the new model as they are refreshed.
- Beyond five years – achieve fully automated IT operations.

10.2. Introduction

IT operations includes the processes and services provided by IT to internal and external customers, and used within the IT department to manage the IT estate. This includes the provision of new IT requirements and services, service desk, operational monitoring of network and server infrastructure, application maintenance, and patching.

It is increasingly important to provide a frictionless user experience in all aspects of the IT service. This includes ensuring high availability by maximising uptime of the applications users rely on, providing efficient self-serve capability for requesting new services, and resolving issues before users are impacted. To ensure the effective and efficient delivery of services, IT operations needs key technologies and tools.

IT operates interrelated processes to plan, build, provision, and operate the services required by our business. These are grouped into four categories.

- Plan – understand business strategy and translate it into an investment portfolio that is optimised to add maximum value to our organisation and its customers.
- Build – from requirement capture to deployment of new applications and IT services.
- Provision – from user/customer request through to the provision of services to users.
- Operate – the detection through to correction covering the monitoring, operating and remediation of the services IT provides.

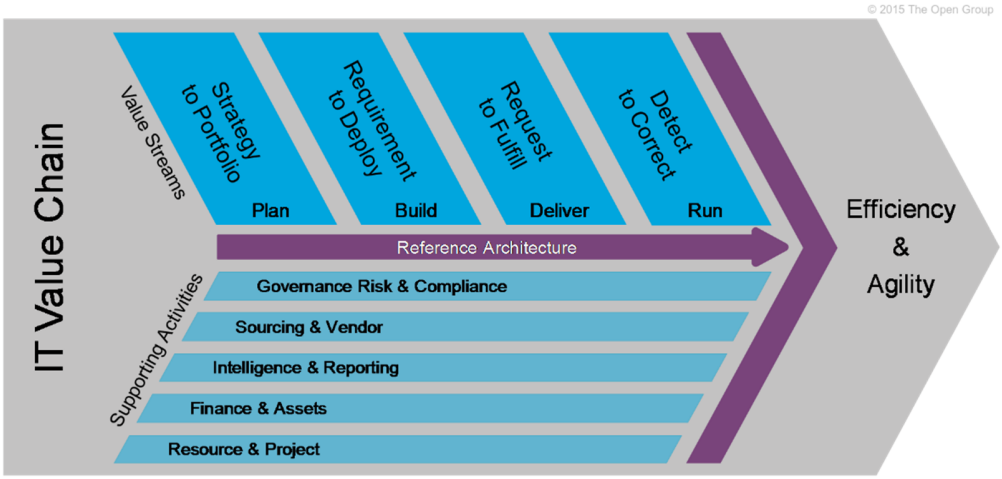

Figure 100 - Solution path for infrastructure automation, Gartner, July 2019

We will identify opportunities to digitalise the operation of each process through improved tooling and automation. Our primary approach remains the streamlining of business processes through process re-engineering and using modern platforms – such as ServiceNow and DevOps tools – which support end-to-end processes. Increasing use of automation, robotic process automation (RPA), and machine learning, can result in substantial efficiency improvements. Our objectives are to reduce costs, increase pace and throughput, and reduce business risk. Automation is also necessary to manage the increasing scale and complexity of IT.

During RIIO-1, considerable emphasis was put on improvements to the provision and maintenance processes. Working with our strategic partners, we established ServiceNow as our primary service request and incident management platform. This enables further opportunities to digitalise IT operations such as application performance monitoring, automated provisioning, and a centralised operations centre.

More recently IT has started to digitalise several build processes such as the use of automated testing and automated provisioning of test, development and training environments. We are investing in DevOps as a step towards continuous integration and continuous delivery (CI/CD) of new and enhanced services into production.

Digital transformation offers new opportunities for a business to drive value. To support this approach, IT also needs a similar step change to make use of advances in software automation, application performance monitoring and intelligent IT orchestration.

We will apply this digital philosophy to all IT functions, from planning to operations.

Plan – digital planning and prioritisation

This covers all activities associated with planning the introduction of new or improved IT services. It includes understanding the business and IT strategic roadmap and requests for new or improved services. Given the amount of proposed investment over RIIO-2 period it is critical this is planned appropriately and sequenced to deliver greatest value.

Demand, portfolio, project and architecture management

IT is investing in new tools to improve planning and prioritisation capability including planning, demand management, resource planning, financial forecasting, cost management, application portfolio management and technology rationalisation. We will consolidate multiple tools into a single platform with a business intelligence layer across information sources to make better informed decisions.

The objectives are to make the most effective decisions based on real data about the existing and future IT services, their costs, health and configuration. This scenario planning capability will help to model the impacts of decisions before they are made.

Financial management and technology business management

We have invested in Apptio to give greater insights into the costs of existing services. Our roadmap includes integration with strategic planning system and with our configuration item management database (CMDB). This will provide a richer view of IT assets and their health through automated asset discovery, software licence management, and cloud access brokers. This will be extended to provide a full view of IT finances covering the cost of operation and future investment/cost to achieve data. Using financial management tools also allows more detailed benchmarking of performance against peer groups.

Similarly, there are opportunities to improve lifecycle management and the planning of technology upgrades. Automating the analysis of vendor support lifecycles against our CMDB data allows for improved prioritisation of upgrade or replacement investment. We will also use

the CMDB data to provide transparency of IT financial performance focusing investment to achieve the greatest impact.

Within a regulated environment, these tools create the ability to apply consumption based financial modelling. This ensures that costs are correctly allocated, driving accountability into the operational businesses for their technology decisions.

These investments will improve transparency, traceability, and monitoring of progress against the commitments within our strategic plans.

Build – automating the development and release of services

Development and integration teams are challenged to deliver a greater volume of change on a more frequent basis. Historically, automation has been applied to parts of the development process, such as automated testing tools to execute unit, stress (load), or regression testing. Agile development practices and DevOps processes are used to further increase the speed of delivery, using tools which improve speed through integration and automation of development tasks.

Within operations, automating the provision of IaaS and PaaS has been the first step. Other opportunities exist and organisations are moving to CI/CD which combines build with continuous infrastructure automation.

Continuous integration covers the build, integration, testing and delivery of functional changes to software on a scheduled, repeatable and automated basis. Extending infrastructure automation to support DevOps processes allows for repeatable and scalable CI/CD processes. With continuous integration, software development teams can use automated and repeatable build and test processes. Code management, version control, regression testing and deployment are managed.

Continuous delivery extends this from compilation of new/amended software, assembly as a build package, testing, and deployment into the relevant environments within a repeatable framework. This can lead to what Gartner terms as continuous infrastructure automation (CIA), with the ability to deploy any change rapidly, safely and on demand at any time.

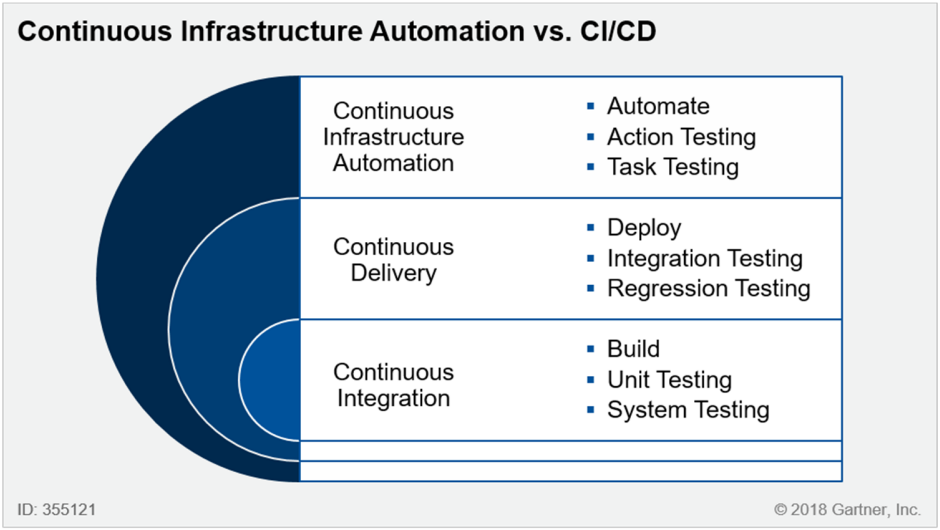

Figure 101 - To automate your automation, apply agile practices and DevOps tools to infrastructure and operations, Gartner, 2018

CI/CD is not appropriate in all circumstances but will increasingly be adopted in areas with high volatility and requirements for rapid change. We aim to adopt CI/CD practices, tools and automation opportunities as they mature.

As our operating model evolves and matures, we will continue to build and enhance our skill sets for the future. Funding models will support more platform-centric programs which concentrate business unit demand around key platforms (for example CRM / Salesforce, asset management, data platforms).

We will also continue to develop new skill sets and automation tools for the build phase in areas such as:

- RPA, artificial intelligence, machine learning, and data science.
- Design thinking/user focused design and lean UX skills/tools for customer journey definition and wireframing.
- Continuing to build cyber skills and tools to embed security in the build phase improving the speed and consistency of cyber protection in applications and services.

Provision and operate – digital IT operations

Provision and operate includes the processes and technologies used within the IT department to manage the IT estate. This includes service requests associated with the provision of new IT requirements and services, service desk, operational monitoring of network and server infrastructure, incident management, and application maintenance activities such as patching and upgrades.

It is increasingly important to provide a frictionless user experience in all aspects of the IT service, ensuring high availability to maximises uptime of the applications users rely on. Users expect efficient self-serve capability for requesting new services and for issues to be resolved before they are impacted. To ensure the effective and efficient delivery of services, IT operations needs key technologies and tools.

Digitalising IT operations can be applied to the following areas:

- Application performance monitoring and management
- Application maintenance
- Provisioning and orchestration
- Fault diagnostics and resolution
- Discovery tooling
- Security automation

Automation is at the heart of this opportunity. As Gartner puts it, ‘automation is a foundational tenet that allows organisations to cope with the rapid pace and scale of digital business.’[11]. Increasing the role of automation in IT operations accelerates time to value, improves the user

[11] Gartner - Hype Cycle for I&O Automation, 2019, p. 2

experience, and reduces waste by making possible the No Ops[12] model where systems need little or no manual intervention to run.

In RIIO-1 we negotiated new contracts and created an application development and maintenance framework with several key partners. These contracts were written explicitly to drive our partners to automate processes. We will continue to build on this through the RIIO-2 regulatory period ensuring alignment between our environments and platforms and those created and operated by our partners.

Digital IT operations – application maintenance

IT operations technology will enable faster development cycles. Advances in automation, application performance monitoring (APM), and tools to create production environments will require less people to run and afford greater insight into performance and increase uptime.

The opportunity is to build environments specifically designed to extract comprehensive performance data and to use this to then drive automation. This enables a long-term goal of a No Ops model where systems need little or no manual intervention allowing resources to be focused on value-add activity.

Designing for automation brings benefits throughout the software development lifecycle as it enables rapid progression from build to test to deployment and operations. Such a step change has the potential for an improvement in uptime, accuracy and efficient use of resources.

This approach has a cumulative effect creating a virtuous circle that starts with real-time performance data and automation, leading to enhanced user experience and rapid development cycles, which creates more opportunity for innovation and value-add activity.

Use of automation has already delivered benefits. The privilege user access review (PUAR) is an example saving significant FTE hours by applying RPA. In this case, a two-hour manual task is transformed into a sub-minute RPA driven transaction, enabling what used to be an 80-day audit to be run over night and with greater accuracy.

[12] "According to Gartner's 2018 Hype Cycle for Performance Analysis, DevOps and AIOps are the two areas that have gained the most momentum in the industry. We need to think of DevOps as the beginning of a bigger, business-critical journey towards a more automated future through AIOps and, ultimately, NoOps — the point where an IT environment becomes so automated that a dedicated team isn't even needed for managing tasks anymore." https://www.lumeer.io/devops-to-noops-with-ai-in-2019/

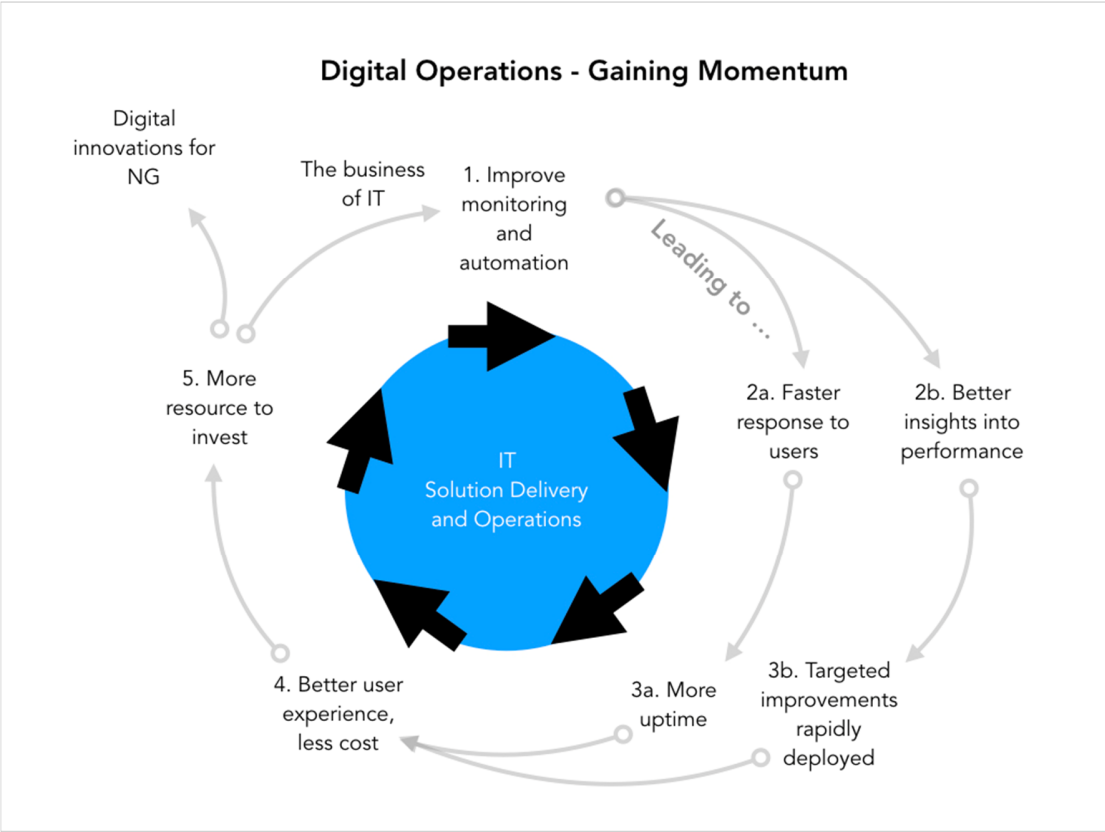

Figure 102 - Digital operations gaining momentum

This approach is tailored for industry standard systems and the bespoke solutions which are unique to the energy industry or developed in-house by us and our partners. A key principle of this approach is to differentiate between support of bespoke applications from the support of commodity SaaS products because each requires a difference focus. For SaaS products, the principles around APM may apply, but there are less opportunities for automation. The focus for SaaS support is more focused on configuration and business process management.

Bespoke	SaaS
Focus on code, innovation, rapid development, automation, environment control, continuous improvement of functional and non-functional attributes	Focus on integration and business process regression testing, configuration, IAM and Security to accommodate vendor upgrade cycle
Technology driven	Business process driven

Digital IT operations – infrastructure and operations

The infrastructure and operations (I&O) area of IT plays a critical role overseeing IT infrastructure and service management, solution delivery and governance across user devices and services, network connectivity, and compute platforms including SaaS, PaaS, and IaaS.

We will invest in process improvements and tools delivered to all critical I&O functions:

- Operations management and governance – we will maintain our asset health policy to improve performance, reduce risk and deliver greater value. The use of common platforms and rationalising how infrastructure and applications are deployed and consumed, will reduce overlap and costs.
- Availability and capacity management – process improvement, automation, and analytics will deliver a deeper understanding of our IT services and infrastructure consumption, providing a predictive forecast to identify when and where we need to deliver capacity.
- Asset management – investing in infrastructure discovery tools will deliver a granular view of our infrastructure inventory, enabling us to correlate infrastructure, applications and services, saving time and reducing costs.
- Change management – change management needs to reach a maturity level where automation and standard changes reduce the time to deliver infrastructure improvements while reducing the risk or failures. The CMBD will play a key role in documenting the relationship between infrastructure, applications and services that will enable the automated risk evaluation, service testing, and validation.
- Service desk – relying on bots and pre-defined or automated steps to remotely apply configuration changes or fixes to software and applications will reduce our service desk footprint.
- Incident and problem management – the combination of application/service performance monitoring tools and automated CMDB discovery can improve visibility and automate problem detection and resolution.

Digital IT operations – fault diagnostics and resolution

Automation allows for more rapid diagnostics of faults, and automation of fixes to resolve faults.

Current practice relies on manual investigation often by multiple suppliers – which can be a significant portion of the total recovery activity. Our analysis showed that the time from initial impact to diagnosis of the fault accounted for an average 54% of total impact time in the three case studies.

We will invest in process improvements and tools:

- Technology roadmap and release management – as part of our proposed plan to maintain a healthy and up to date environment, I&O will use automated CMDB discovery tools to track hardware and software inventory to plan and deliver the necessary updates to the infrastructure. Automated patch management utilising artificial intelligence validated releases will improve update cycles to reduce operational and security risks.
- Performance measurement – developing a baseline for infrastructure, applications and service performance using tools and machine learning to measure and predict performance issues before users report problems will allow I&O to track user experience and reduce the number of incidents.
- Application performance monitoring – allows IT to measure the real user experience of an IT application in terms of its availability and responsiveness. Historically, when performance degrades, the first alert is generally the users calling the service desk. Consequently, the user experience can suffer for prolonged periods while IT reactively addresses the issue.
- Cost and operational budget management – we will use cost management tools like Apptio in combination with automated infrastructure inventory and CMDB discovery. Integrating with SAP, billing management, and our strategic planning tools will allow I&O

and IT finance teams to improve visibility, track cost allocation, and measure performance against the targets.

- Service catalogue – investing more on delivery of standard services and solutions will improve our time to deploy and reduce costs via automated workflows and change management. It is important that we revisit our service catalogue taxonomy. The taxonomy is critical to delivering a rational, frictionless end user experience.
- Disaster recovery and business continuity – as the technology deployed within the IT estate changes with the adoption of new network and storage technologies, it is necessary to continually update and test business continuity and disaster recovery plans. Standard infrastructure solutions will enable I&O to deliver the required availability at a reduced cost, delivering the level of assurance required to ensure business continuity in case of a major disaster.
- Supporting tools – IT service management tools are vital for I&O to deliver IT services in a frictionless and cost-effective manner. During the RIIO-2 period we will extend the functionality of our ServiceNow platform to include CMDB which, in conjunction with Apptio, will deliver transparency of the IT cost base enabling effective decision making and driving ever greater efficiency within the portfolio.
- SaaS support – for the support for SaaS products, the emphasis is placed on business functions and their role in maintaining the business processes within the tool. The role of I&O is to ensure the basics of network connectivity, end user computing and support desk functions are in place.

Digital IT operations – application performance monitoring and maintenance

Application performance monitoring allows IT to understand the real user experience of an IT application in terms of its availability and responsiveness.

Historically, when performance degrades, the first alert is generally the users calling the service desk. The user experience can suffer for prolonged periods without IT being aware there is an issue.

At present, production environment monitoring is disjointed and incomplete. Root cause analysis is a manual and time consuming task. Where implemented, APM is retro fitted and incomplete so of limited value. To extract maximum value, systems need to be designed for APM with the aim of exposing rich data on performance.

Designing in automation and monitoring from the start overcomes these problems as it enables the production environment to create rich application performance data insights to drive artificial intelligence learning and latterly automation via orchestration tools.

Automation, performance monitoring, and artificial intelligence present opportunities which were previously out of reach. Gartner describes artificial intelligence for IT operations (AIOps) platforms as emerging but predicted to be transformational in five to ten years, leading to: agility and productivity gains, service improvement and cost reduction, and mitigation of risk[13].

We will adopt these guiding principles:

- Bespoke IT solutions are designed to be deployed and operated without manual intervention.

[13] Gartner - Hype Cycle for I&O Automation, 2019

- Performance monitoring is comprehensive and exhaustive.
- Tools supporting the environment are best of bread and integrated with a single orchestration layer from which actions can be automated.
- Intelligent operations tools use artificial intelligence and machine learning to detect out of bound performance and suggest root causes of failure.
- Principles are strictly applied to qualify applications to run in this environment.
- System improvements are driven by performance data insight, so changes are targeted and efficient.
- New releases are baselined against existing operational performance data, so they are proven before deployment.
- Automation is used throughout the build and test process allowing nightly build and test cycles.
- A modular build approach combined with short development cycles and continuous and automated build/test enables IT to confidently and flexibly adapt solutions to support new business opportunities.
- Software is built and tested against the same APM tools as used in the production environment.
- All suppliers/partners have visibility of the production environment performance data which is regarded as the source of truth.

In the short term (zero to two years) we will surface data and implement APM across the existing production environment where compatible. This includes user experience monitoring, automated inventory management, and full software/infrastructure performance monitoring. The outcome is to gain control of the environment, increase uptime and enhance the user experience.

In the medium term (two to five years) we will repurpose applications as they are refreshed through reinvestment. Generic services are provided by vendor platforms, bespoke solutions are designed accorded to the mandated principles, which are fully verifiable in the test environment. Solutions are modular, frequently iterated and rely on automation for deployment and operation. Over 80% of events are fixed without manual intervention. Application maintenance costs are reduced enabling more resources to be directed to developing solutions to support the business.

Long term (five years plus) we will remove IT operations. Artificial intelligence and orchestration have enabled applications and infrastructure to run with minimal manual intervention, delivering significant reduction in operational cost.

Digital IT operations – discovery tooling

As the rate of change increases across the IT landscape through increased automation, then the need for automated discovery tooling also increases. Automated discovery tooling enables information to be collected on services, hardware, and software, in real-time ensuring information is up to date in a rapidly changing environment. This is required to address several key areas:

- Software and service license compliance – an accurate inventory of software and services and their licensing usage is critical to ensure that we remain compliant with the terms of our licensing agreements.

- Cost management – an accurate cost of services is key to decision making and cost transparency. This will enable us to operate services most efficiently to meet customer demand.
- Configuration management – accurate configuration management information is critical for incident resolution/change management to ensure that planned or unplanned changes have the desired effect on the services being impacted. Out of date information can lead to intervention errors and inadvertent loss of service.

Strategic platform investment areas

Demand, portfolio, project and architecture management

Aligning business strategy and demand to change initiatives and the underlying architecture is critical to managing change efficiently and cost effectively. A consolidated platform, or set of integrated products, will ensure alignment and visibility across the planning and execution lifecycle. In RIIO-1, investments have been made to maintain and integrate point solutions. This will need to improve and increase throughout the RIIO-2 regulatory period to optimise the delivery of RIIO-2 investments.

Disaster recovery

Disaster recovery is an area of IT and security planning that protects us from the effects of a significant negative event, allowing the quick resumption of mission critical functions. We create and manage large volumes of electronic data, much of which is essential to the normal operations of the business. While every effort is made in the design of IT solutions to prevent outages impacting users, it is not practicable to engineer full resilience to every system.

As the technology deployed within the IT estate changes with the increased adoption of cloud compute, new network and storage technologies it is necessary to continually update and test business continuity and disaster recovery plans.

Discovery Tooling

The large and dynamic nature of our IT estate creates specific challenges in maintaining an accurate view of the assets and software packages deployed. One of the key requirements in digitalising IT operations and extracting the benefits of artificial intelligence and automation is tracking the configuration of the IT estate. A CMDB which is continually monitored, updated and verified by discovery tools, plays a vital part on the digitalisation journey.

ServiceNow

Within the digitalised IT operational environment frictionless workflows to support change management, and orchestrate the automated workflows associated with customers requesting new technology and applications are a vital component of driving operational efficiency and improved customer experience.

The ServiceNow platform is our platform of choice for the provision of digitalised workflows transforming the IT value chain allowing IT to align to the business priorities with speed and agility, delivering artificial intelligence powered user experiences whilst reducing operational costs. IT service management tools are vital for I&O to deliver IT services in a frictionless and cost-effective manner.

We adopted ServiceNow during the RIIO-1 period. This allowed us to consolidate our IT service management systems and processes that were previously spread across multiple platforms and offline spreadsheets. From this, we started to generate the vital data, analytics and reporting capabilities required to drive the function forward and improve efficiency.

During the RIIO-2 period we will build on these foundations and extend the functionality of our ServiceNow platform to include CMDB. In conjunction with APPTIO, this will deliver transparency of the IT cost base enabling effective decision making and driving ever greater efficiency within the portfolio.

Core to efficient and effective IT service management is a robust, reliable CMDB. Improved CMDB data stewardship and management will contribute to a reduction in service outages and enable faster incident resolution.

Software asset management provides the ability to set up license abstracts, implement automated license reuse and act upon various license thresholds. To derive maximum value in software asset management, we will need to invest in the ServiceNow software asset management module. This functionality provides transparency and reporting becomes near real-time. This avoids extensive work each time we need to accurately identify overlaps in an increasingly complex licensing model. We can then monitor and rationalise our technology estate in real-time without months of resource-intensive analysis.

ServiceNow allows IT to interface directly to other key business services, linking to identity access management (IAM), Successfactors (HR system), and SAP allowing the creation of workflows across a wide range of business services, further improving efficiency of the enterprise.

ServiceNow is a constantly developing platform with incremental capabilities being released in twice yearly updates. Continued investment is required to ensure that we derive maximum value from the new capabilities as they are added to the platform.

Infrastructure and network operations centres (iNOC)

Within the our estate, there are multiple network operations centres, each supporting specific assets and providing specific monitoring capabilities. These include teams to support the OPTEL network management, CNI system health, enterprise network monitoring, data centre monitoring, and cyber security operations. These functions operate independently across multiple locations, each with independent management and reporting lines. These operation centres also reflect the functional responsibilities of each of our strategic service partners.

As the IT estate becomes increasingly digitalised, reducing the need for manual intervention in the operation of the IT estate, the standalone nature of the varied iNOC capabilities within the estate becomes increasingly inefficient and less effective than it could be if integrated into a single unified operations centre.

The network operation centres have a key role in enabling us in managing the performance of vendors by being able to directly monitor and interrogate the systems, without being dependent on reports provided by the vendors. Our ability to scrutinise asset discovery, network monitoring, application performance monitoring, and similar tools plays an important role in validating the performance of vendors and providing quantitive data against which to identify and define improvements.

In bringing all independent iNOC capabilities into a single function we drive efficiency by eliminating the multiple management structures required, streamlining to a single line management structure. A single unified iNOC will also improve the effectiveness of communication and cooperation between capabilities by bring them together and improve our overall capability by bringing in-house monitoring and reporting on the holistic IT estate.

The intent of infrastructure and network monitoring capability is not to function in independent silos. As technology becomes ubiquitous in modern workplaces and greater levels of automation are available, it is important to address our legacy services and redefine how of

technology will be monitored and managed into the future. Failure to address the historical technology monitoring will perpetuate elevated costs, impair improvement in service, and most critically, block the future automation of technology management.

Once enabled with the required infrastructure and tools, the iNOC will deliver end-to-end visibility across our infrastructure and partners.

10.3. Options

In reviewing the options to deploy automated IT operations, it became apparent that there is little benefit in selecting individual parts of this strategy.

While benefits may be achieved in streamlining the management of iNOC under a single line management and location, that would not deliver the benefit to justify the activity in value for money terms.

The significant benefits are only realised by delivering automated and digitalised operations, where artificial intelligence and machine learning proactively monitor application performance. The reduced dependence on reactive outage investigation and resolution not only deliver considerable benefits to user experience, but also deliver substantial operational savings.

Discovery tools that monitor the configuration and performance of the IT estate provide effective and accurate cost allocation and control. This transparency of accurate data enables effective decisions on cost drivers and ensures that the implications of investment decisions are understood.

The automation of IT operations extends to the provision of new user services through self-service portals. These portals manage the end-to-end workflows providing automated delivery and improving the user experience.

Each of these capabilities are interdependent. The removal of one significantly impacts the whole, diluting the benefit of both in terms of value and experience. It is considered a binary choice – perpetuate the current operational model with constrained operational benefits, or adopt new capabilities and achieve value through the operational cost savings.

Table of options considered

Option	Total Cost of Ownership	Capacity to Deliver	Business / Strategic Fit	Addressing the problem	Risk	Overall
Do nothing (Minimal / no automation investment) – Continue or reduce existing levels of automation and use manual activities and processes.	**RED** • Highest cost due to increase in staff costs over efficiency gains from automation and digitalisation . • Lower investment in technology. • Increased cost to implement and manage change.	**AMBER** • Challenges in on boarding and maintaining the required staffing levels. • Risk to successful delivery of IT elements of critical initiatives.	**RED** • Increased service disruption as interdependencies and complexity increases and inconsistencies through non-repeatable processes. • Less resilience for IT systems. • Reduced cyber security. • Increased cost to run and maintain IT services. • Poorer customer and end user experience. • Suboptimal decision making as information not current.	**RED** • Does not address the challenges with customer and user experience . • Does not provide accurate enough information for decision making.	**AMBER** • Increased risk of service disruption through system outage through human error, cyber-attacks and incorrect decisions based on incorrect data.	**Rejected** • Highest cost option. • Introduces significant risk to services and service resilience.

Option	Total Cost of Ownership	Capacity to Deliver	Business / Strategic Fit	Addressing the problem	Risk	Overall
Use near or offshore resources (Minimal/no automation investment) – Continue or reduce existing levels of automation and use manual activities and processes.	**AMBER** • Lower cost than building out IT organisation onshore. • Lower investment in technology. • Increased staff costs due to the volume of staff needed to achieve desired outcomes. • Increase in cost to extend capabilities and capacity in other locations. • Increased cost to implement and manage	**AMBER** • Challenges in on boarding and maintaining the required staffing levels. • Risk to successful delivery of IT elements of critical initiatives.	**RED** • Increased service disruption as interdependencies and complexity increases and inconsistencies through non-repeatable processes. • Less resilience for IT systems. • Reduced cyber security. • Increased cost to run and maintain IT services. • Poorer customer and end user experience. • Suboptimal decision making as information not current.	**RED** • Does not address the challenges with customer and user experience. • Does not provide accurate enough information for decision making.	**AMBER** • Increased risk of service disruption through system outage through human error, cyber-attacks and incorrect decisions based on incorrect data.	**Rejected** • Less cost than 'do nothing', but still significantly more expensive in opex in the future • Introduces significant risk to services and service resilience.

Option	Total Cost of Ownership	Capacity to Deliver	Business / Strategic Fit	Addressing the problem	Risk	Overall
	change.					
Targeted automation investment – Invest in some areas identified as providing the highest returns.	**GREEN** • Good balance of investment and reduction in operating expenditure. • Increased investment in technology. • Increased staff costs due to the volume of staff needed to achieve desired outcomes but not as much as options 1 and 2. • Increase to cost to implement and manage	**GREEN** • Challenges in on boarding and maintaining the required staffing levels. • Risk to successful delivery of IT elements of critical initiatives.	**AMBER** • Realises some benefits but not all. • Still Increased Service disruption as interdependencies and complexity still exist and inconsistencies through some non-repeatable processes. • Less resilience for IT systems. • Reduced cyber security. • Increased cost to run and maintain IT services. • Poorer customer and end user experience. • Suboptimal decision making as information	**RED** • Does not address the challenges with customer and user experience. • Does not provide accurate enough information for decision making.	**AMBER** • Risk of service disruption through system outage through human error, gaps in automation, cyber-attacks and incorrect decisions based on incorrect data from the gaps in automation tools.	**Rejected** • Less cost than options 1 and 2 but does not deliver optimum operational expenditure benefit. • Still holds significant risk to services and service resilience.

Option	Total Cost of Ownership	Capacity to Deliver	Business / Strategic Fit	Addressing the problem	Risk	Overall
	change.		not current.			
Targeted investments in automation - Retain existing levels of automation and manual activities.	**GREEN** • Best balance of investment and reduction in operating expenditure. • Maximum investment in technology. • Lowest staff costs. • Lowest cost of ongoing change.	**AMBER** • Some challenges exist to implement a comprehensive set of automation tools and capabilities. • Will leverage our partners and contracts to assist with initial implementation. • Will extend relationships with strategic platform vendors.	**GREEN** • Realises all defined benefits and is the best for option to support the business strategy. • Reduced service disruption as interdependencies and complexity removed and consistency through repeatable processes. • Improved resilience for IT systems. • Improved cyber security. • Lowest cost to run and maintain IT services. • Improved customer and end user	**GREEN** • Addresses all challenges with customer and user experience. • Provides accurate information for decision making.	**AMBER** • Some identified risk to implement a complex set of automation tools and processes. • Risk being mitigated by leveraging partners to supplement expertise.	**Recommended** • This option requires the highest level of investment in several automation tools and platforms but provides the most optimal management of the business of IT and the least operational expenditure for the future IT organisation.

Option	Total Cost of Ownership	Capacity to Deliver	Business / Strategic Fit	Addressing the problem	Risk	Overall
			experience. • Optimal decision making with current, up to date information.			

10.4. Key assumptions, dependencies and risks

The operational efficiencies afforded by digitising IT operations and creating a unified operations centre are dependent on the updates to IT technology proposed in 'shared investments: enterprise data networks' and 'shared investments: hosting'. Without the modernisation of the IT estate proposed it would not be possible to digitalise IT operations sufficiently to enable the artificial intelligence and automation that releases the proposed savings. Without the automation delivered by the digital operations proposal we would not be able to deliver the full benefits proposed by unifying out network operations centres.

- Costs and options are based on available technical solutions. New or disruptive technology may provide additional technical alternatives at the time of implementation.
- It is assumed that all IT projects are progressed and funded, removal of one or more deliverables may impact the options analysis and cost assumptions associated with the remaining deliverables.
- There is a risk/opportunity that the level of coordination between IT operations automation and other projects will vary from the levels assumed. Where possible we will use projects to deliver efficiencies with a resultant impact to cost.
- The primary contingency for these proposals will be an increase in staff and manual effort to cater for the increased demand for change across the IT estate, this could be delivered through permanent, contract, or IT partners.

10.5. Conclusions

A digital business is a new business model, and digital transformation applies technology to deliver step changes to address business problems. The same thought leadership can be applied to the internal workings of IT to ensure it has the structural coherence to deliver on its promises.

Automation can unlock improvements in efficiency and effectiveness, leading to improved user experience, less downtime, more agility and less waste. It can also unlock a virtuous circle of agility and efficiency gains as momentum builds.

While still an emerging field, Garter predicts automation will be 'transformative' in a five to ten-year horizon. There is merit in starting to build automation so we have the skills and experience to exploit the technology fully when it matures.

To unlock these benefits all systems will need to be designed to be monitored and automated. This will mandate design principles for development and architecture. The alignment of the pipeline will have benefits because the goals are overlapping.

Doing so will involve a shift in thinking to extend the DevOps principle of continuous build and integration into the realm of IT operations. These principles will shape future systems to be automation ready.

Production environments will need comprehensive APM capabilities so performance at all levels is exposed. Once consolidated in an orchestration layer this data can drive artificial intelligence engines for heuristic learning and automated management of software and systems.

The implementation path begins with pilots to prove the principles and then scaled through the next round of portfolio investment. Once sufficient automation experience has been amassed, the transformation of IT operations and other IT processes can begin.

11. Shared investments: enterprise data network

11.1. Executive summary

National Grid group's enterprise data network, which comprises the wide area network (connections between sites) and the local area network (the network within sites including wireless networks), supports data and voice communication services essential for the safe, secure, reliable and economic operation of our businesses. Failure of these services significantly compromises our ability to deliver on our commitments to customers and consumers.

Our strategy to assure the continued secure, efficient operation of these network services is to:

- Use the National Grid group operational telecoms Optel network to avoid duplicated costs when connecting to operational sites.
- Shift from expensive private/dedicated connections to lower cost shared public connections.
- Adopt a technology agnostic approach that ensures flexibility the adoption of future technologies and does not favour technology or individual supplier agendas.
- Use virtualised computing hardware rather than dedicated network appliances to reduce costs, simplify service upgrades, and shift focus from hardware to software-based solutions.
- Transition our local area networks within our sites and offices from a predominantly wired network to wireless networks to reduce costs of our local area network (LAN) infrastructure. This enables a smart workspace environment that maximises space/occupancy and promotes collaboration.
- Maintain a competitive network partner system to deliver the best service and value for customers.
- Use current investment in laptops and mobile devices to support the use of softphones for employees to replace expensive office phones and reduce costs, improve colleague productivity, and maximise occupancy of our offices.
- Maximise the secure and useful life of our data network assets in line with our network refresh policies to balance the cost of services and performance.

We analysed six options (three WAN and three for the LAN) against the overall total cost of ownership, strategic fit, the extent to which the option meets customer needs, overall risk and our capacity to deliver. All but two were rejected as either not affordable or failing to meet the minimum operational/compliance requirements for the secure operation of the network. All options are detailed below, with option two for both WAN and LAN recommended as representing the appropriate balance across all evaluation criteria.

Our recommended approach is to invest a total of £46 million as a group (£12 million allocation for ESO) during the RIIO-2 period with early investment across all network services to maximise the benefits for customers and payback.

	2021/22	2022/23	2023/24	2024/25	2025/26	Group Total
LAN infrastructure	5.8	4.8	9.1	4.4	3.8	27.8
Network security infrastructure	0.0	0.0	0.0	0.0	0.0	0.0
Voice infrastructure	0.0	0.0	0.0	0.0	0.0	0.0
WAN infrastructure	3.6	7.2	2.9	2.3	2.6	18.6
Total	**9.5**	**11.9**	**12.0**	**6.7**	**6.3**	**46.5**

Figure 103 - Group capex investment in hosting, 18/19 pricing, £ million, opex not shown.

We will ensure competitive commercial advantage by balancing the length of contract with efficiency commitments for customers. We have reviewed our investment plans and asked Gartner to challenge our execution strategy. All investments benchmarked well within Gartner's independent assessment.

11.2. Introduction

Enterprise data network services enable connectivity (virtually transparent to the user) for almost all IT activity. Ageing network infrastructure can add delay to each process or operation, where even an additional second or two to each daily action can significantly affect productivity. So it is essential to the safe, efficient and reliable operation of the network that IT infrastructure is maintained and updated.

The enterprise network comprises the wide area network and local area network (including wireless networks) that support voice and data communication.

The scope of the network services is summarised in the table below.

Network Service	Description	Volume	Value
WAN	The wide area network (WAN) provides connectivity for National Grid sites/offices and data centres. It supports both the transmission of	307 UK National Grid and	Provides access to shared computing resources and applications. Supports

Network Service	Description	Volume	Value
	data and voice services, allowing our employees to use shared applications, shared data, telephony and internet (cloud) services. This supports the day-to-day running of the National Grid business	partner sites 413 Routers	processes and services across the enterprise.
LAN including wi-fi	The local area network (LAN) provides access for devices (e.g. desktops and laptops) to the National Grid enterprise network and resources in the WAN and LAN. Access to the LAN can be both wired and wireless. The wireless local area network (WLAN) provides access for devices (e.g. desktops and laptops) with WLAN or wireless LAN capability to the National Grid enterprise network. To support WLAN access, the wireless access points (WAP) are needed at the user locations. WAPs are essentially small radios connected to the enterprise network that transmit information between wireless user devices and the network to eliminate the need for user devices to be wired to the network.	1015 LAN switches 912 wireless access points	Reliable and flexible access to network and resources.
Voice	National Grid's business telephony is provided by an IP telephony service where voice services are transported over the WAN and LAN data network. This is enabled by QOS (quality of service) tagging on the network that prioritises voice services over other traffic. Contact centre services are operated over the data network to eliminate the need to manage both a voice and data network and reduces cost of connectivity and management.	6,000 user accounts	Reliable, high-quality voice services. In addition to individual voice services, supports reception and conference phones and reliable service for safety and security use. Also enables use of hunt groups and other group calling features.

Failure of these services would severely impact the ability of ESO to deliver on its commitments to the public and other business partners. Our network infrastructure is largely made up of legacy configuration, requiring substantial monitoring and manual change management for daily operations and is at, or approaching, end of life.

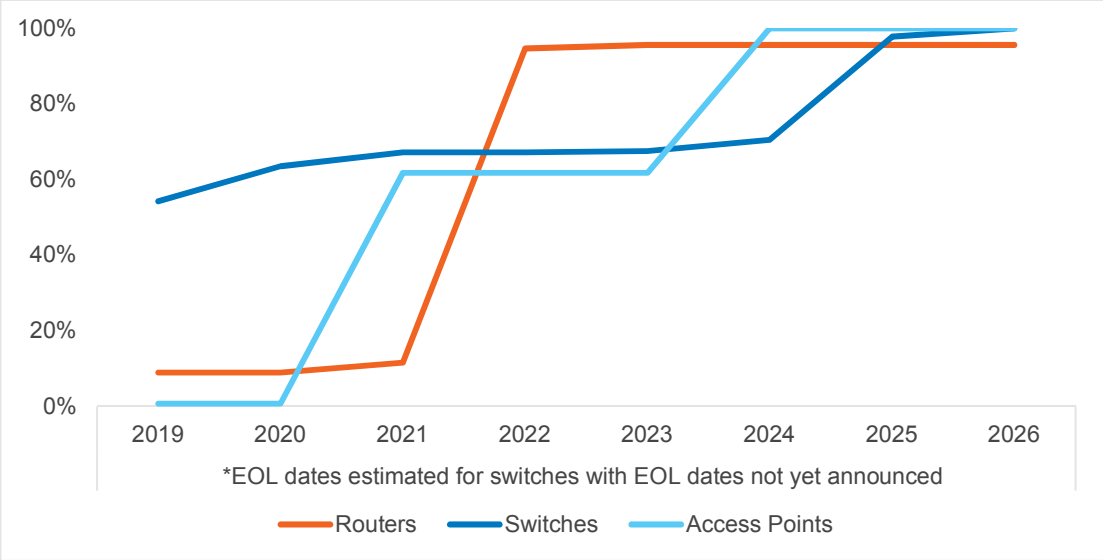

Figure 104 – Percentage of network devices reaching end-of-life (EOL) by year

Implementation of a modern, software-defined network architecture and a redesigned LAN capable of monitoring and automated provision would reduce the risk from ageing assets, enable the adoption of cloud-based services and drive greater efficiency.

11.3. RIIO-1 background information

At the start of RIIO-1, we responded to the challenge to reassess our IT asset health policies by extending the live of our IT infrastructure assets, accepting higher levels of risk whilst maintaining availability. In the short term, consumers benefited financially from the deferral of this investment in our infrastructure.

As we continued through RIIO-1, our employees fed back that IT was becoming a significant blocker to their effectiveness. Specifically, users need to be able to collaborate, access more cloud services and use large-scale analytics. The National Grid WAN and LAN have constrained how we take advantage of these services.

Over the same period, the escalating threat of cyber attack on our IT systems meant we revisited how we monitor and block cyber threats to our infrastructure .

As we look forward to the RIIO-2 period, we are proposing an asset refresh with ongoing lifecycle asset management to address these challenges. In addition to the reliability, operational and security benefits, the convergence of IT virtualisation, proliferation of

wireless devices, and availability of low cost internet service has created the opportunity to not just refresh, but transform the network architecture to support the rapid adoption of cloud-based services and the transition to a mobile user workforce.

Benefits include:

- Use of public networks (wired and wireless) for network transport to lower WAN costs and improve resilience and provisioning time.
- Prioritise traffic flow to meet application service level agreements (SLAs).
- Reduce management overheads.
- Migrate high-cost proprietary network hardware and appliances onto general platforms.
- Transition to a wireless work environment to improve efficiency and collaboration and reduce the cost of office IT infrastructure.
- Delivery of proactive monitoring to detect problems before they impact users, improving service performance and user satisfaction.
- Support anticipated increase in network traffic. Given the growth of connected devices and cloud services, we will be able to support the anticipated fifteen to twenty per cent year-on-year network traffic growth.

National Grid Group IT has undertaken a detailed technical and cost benefit analysis and concluded a need a group investment of £19 million in the WAN and £28 million as a group in the LAN/voice environments during the RIIO-2 period by implementing:

- A virtual, software defined wide area network (SD-WAN) infrastructure that delivers network routing securely. SD-WAN can provide WAN connectivity via both the private network using private transport technologies like MPLS, 5G and/or direct internet access. This architecture allows us to take advantage of lower cost public networks for WAN connectivity and provide direct internet access in support of cloud and SaaS services. This will also allow us to reduce the frequency of bandwidth upgrades to our internet gateways.
- A redesigned LAN environment that uses automation and proactive monitoring to deliver high density wireless local area networks (WLANs). These support smart workplace with connected user mobility for user collaboration and more effective use of building space.

These investments are vital to the modernisation of the IT estate:

- Having up to date infrastructure is essential to maintaining security for a company running critical national infrastructure.
- Old equipment consumes more resources and budget with diminishing return.
- Inflexible and outdated technology makes it difficult to support new business demands and the digital workplace.

- End users are equipped with effective IT tools and connectivity, enabling them to do their jobs efficiently.

The level of investment and the asset health policies that underpin these investments were benchmarked by Gartner, a recognised expert in IT benchmarking. The feedback was that our asset health policies are in line with recognised industry best practice. We also tested each individual investment portfolio against the industry benchmark; our enterprise data network portfolio is positioned in the upper quartile.

What is different for RIIO-2?

- Under the current RIIO-1 structure, we have continued to support the delivery of network services, renewing the architecture where appropriate and modifying services to address new requirements in cloud, wireless, and security. However, as we look to a cloud-based future, the network architecture we have in place needs to be fundamentally changed. As we move into the RIIO-2 period, we plan to execute our updated strategy that delivers a high capacity and cloud-enabled WAN by migrating from our legacy WAN to one that is fully software defined (SD-WAN) and meets our users' need for high speed mobile network access. This will include a redesigned LAN that supports the delivery of a high-density wireless network. As can be seen in the table below, this will require additional funding during the RIIO-2 period as compared to the RIIO-1 period.

	RIIO-1 group expenditures 2014-2021	RIIO-2 group expenditures 2022-2026
WAN	£4.6m	£18.6m
LAN	£11.3m	£27.8m

How does this align with our IT strategy?

- The IT mission within National Grid is to provide technology thought leadership, focus on the end users and deliver reliable and secure services and solutions. The evolution of the network proposed in this document is a direct reflection of this IT mission. Rather than delivering more of the same, the National Grid IT Team has proposed solutions that align with the strategic priorities of National Grid. The proposed SDWAN and its capability to use both public and private network and performance-based routing to deliver an optimal experience for our users is unlike anything we have had before. In addition, the delivery of the SDWAN along with a redesigned LAN that supports wireless services for data, voice, and video will meet our needs today and future proof our business as technology evolves.

Drivers for change

- The key driver for these changes is performance. National Grid needs to provide its employees with the tools they need to perform their job and meet our commitments to our customers and stakeholders without being constrained by technology. The technology needs to be an enabler for our business to deliver. Delivery of this architecture will provide the capacity and security to make best use of cloud services, will expand the Wi-Fi network to allow employees continuous connection will automate and simplify changes to reduce outages and ongoing costs. By keeping our infrastructure current, we will keep up with the pace of change and proactively address possible failure points. To ensure the network meets these performance requirements, we will use LAN-based management platforms and sensors. In addition to focusing on availability, we can now also measure and focus on performance.

Continue to provide a highly available secure service.

- In addition to the new functionality provided by this platform, we will continue to focus on the critical nature of the network and ensure service availability, security, and asset health. We believe the implementation of the new architecture will improve our services in these areas as the new architecture calls for an asset refresh, is designed to handle modern security risks, and has a redundant architecture that uses resilient network circuits and proactive support services.

Our key stakeholders are the users of this technology: employees, customers and third parties who receive services through our networks. Customers and key stakeholders are engaged through regular net promoter score (NPS) surveys and we survey our employees annually. Throughout the RIIO-1 period they have told us that IT is a significant blocker to effective working.

11.4. Options

In arriving at recommended options, we:

- Listened to feedback from users and stakeholders.
- Defined the problem.
- Engaged with our service partners to develop and evaluate options.

We identified the following key criteria:

- Total cost of ownership – capital investment and associated operating costs borne by consumers.
- Capacity to deliver – the level of risk associated with our ability and our supply chains to deliver the option.
- Strategic fit – the alignment of this option to our overall business direction.
- Addressing the problem – how well the option resolves the issue.
- Risk – the overall risk to the business.

We identified a range of options, evaluated against criteria and eliminated non-credible options. We then took forward a baseline do nothing/do minimum option, and other credible options for a cost benefit analysis. The WAN and LAN/voice were broken into two separate analyses:

WAN options analysis

Our enterprise network is based on a traditional WAN/LAN architecture using purpose-built routing and switching hardware connected via private MPLS (multi-protocol label switching) circuits using a LAN with wired endpoints. Due to the critical nature of these services, it is imperative for ageing hardware to be upgraded or replaced to ensure it remains operational with a very high level of availability. In addition, with application delivery approach migrating to cloud, users being more mobile, and cyber security threats increasing, it is critical to include these requirements in our refresh strategy. To meet these business requirements, an SD-WAN environment is planned for the WAN with a WLAN environment for LAN.

The router is the fundamental building block of the WAN. This supports connectivity between our locations. We have 413 purpose-built routers in service today and 391 will reach end of life by 2022. After a detailed review of current market services and technology, we decided to migrate to a software-defined WAN (SD-WAN) using a generic computing device in support of the SD-WAN routing function. This provides several benefits over a traditional WAN. The most notable benefits are the ability to use multiple access methods like a private MPLS connection or internet connection for site connectivity; a performance-based routing engine that selects the most optimal routes for each application; and the ability to access internet and cloud services directly via a local internet connection without having to route the traffic to the main data centre. This will improve access performance at a reduced cost.

The credible options to deliver this service are evaluated in the table below:

Option	Total cost of ownership	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
Retain and upgrade existing network technologies. Replace network assets at EOL with schedule driven by asset refresh policy.	**AMBER** • Costs remain similar to today. • WAN costs for additional bandwidth drop over time. • Future large investment required to upgrade MPLS and VSTIG network to support cloud usage.	**GREEN** • Proven technology from the incumbent network providers. • Use established industry standards as better understood to maintain and expand.	**AMBER** • Supports short-term business need. • Uses established technologies from multiple vendors. • Good availability of skills and knowledge internally.	**AMBER** • Addresses the EOL problem with hardware support and compliance. • Addresses part of the problem with the underlying migration to cloud services. • Does not address large scale move to cloud and use of SaaS applications.	**GREEN** • Removes risks around EOL infrastructure. • Proven technology from incumbent network providers. • Supports short-term business requirements.	**Rejected** • Provides a supportable and maintainable version of the current technology but does not position for future business requirements.

Option	Total cost of ownership	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
Migrate WAN to an SD WAN architecture to realise cost savings and performance improvements (through policy-based traffic routing) over three years.	**AMBER** • Opportunity to replace MPLS links with internet to reduce WAN charges. • Implementation of multiple access methods (MPLS and internet) at sites may result in increased WAN charges. • Local internet services will reduce the cost of future VSTIG infrastructure upgrades.	**GREEN** • Initial SD WAN and cloud-based security deployments under way. • Use of market leading SD WAN software and trusted virtual computing platforms will support the delivery of a reliable solution. • Internet provides access to cloud services without being constrained by WAN and internet bandwidth. • Virtual routers are capable of additional functions.	**GREEN** • Supports current and future business requirements. • Supports move to cloud services. • Supports user mobility and collaborative working. Reduces the need to upgrade VSTIG internet bandwidth.	**GREEN** • Addresses problem of underlying hardware being supported. • Addresses the problem of increased use of cloud services. • Addresses the problem of the increased WAN bandwidth requirements. • Address the problem of VSTIG bandwidth being risky and expensive to upgrade.	**AMBER** • New technology and virtual routing devices have a higher configuration complexity than traditional network devices. • Removes risks around EOL infrastructure in the NG environment. • Removes risk of bandwidth capacity for private and cloud services.	**Recommended** • Meets current and known business requirements. • Provides greater control of applications and bandwidth use. • Maintains security.

Option	Total cost of ownership	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
Migrate WAN to an SD WAN architecture to realise cost savings and performance improvements (through policy-based traffic routing) over three years. Accelerated SD WAN schedule over one year.	**RED** • Opportunity to replace MPLS links with internet to reduce WAN charges. • Implementation of multiple access methods (MPLS and internet) at sites may result in increased WAN charges. • Local internet services will reduce the cost of future VSTIG infrastructure upgrades. • Delivery in one year may not be fiscally prudent.	**RED** • Accelerated timeline may overtax NG and 3rd party suppliers. • Less time to analyse services during delivery that could improve solution. • Initial SD WAN and cloud-based security deployments under way. • Use of market leading SD WAN software and trusted virtual computing platforms will support delivery of a reliable solution.	**GREEN** • Meets our goals faster than Option 2 • Supports current and future business requirements • Supports move to cloud services • Supports user mobility and collaborative working Reduce the need to upgrade VSTIG internet bandwidth	**GREEN** • Addresses the problem of underlying hardware being supported. • Addresses the problem of increased use of cloud services. • Addresses the problem of increased WAN bandwidth requirements. • Address the problem of VSTIG bandwidth being risky and expensive to upgrade.	**AMBER** • Accelerated timeline may overtax National Grid and 3rd party suppliers. • New technology and virtual routing devices have a higher configuration complexity than traditional network devices. • Removes risks around EOL infrastructure Removes risk of bandwidth capacity for cloud services.	**Rejected** • Delivery in one year may not be fiscally prudent. • Meets our goals faster. • Accelerated timeline may overtax National Grid and 3rd party suppliers.

The first option is rejected because it does not address business requirements of additional cost-effective bandwidth and greater use of cloud services. In addition, the traditional approach to delivering WANs uses the same resource-dependent support model with little opportunity to reduce costs.

The second and third options are technically identical, delivering a complete SD-WAN solution that meets all short and long-term requirements. The difference is the delivery cycle. While option three accelerates the delivery of benefits, option two is a more responsible approach due to the current maturity of SD-WAN in its product lifecycle, the overall cost of the program, and requirements that the implementation places on our business resource regarding onsite support and impact of change.

LAN options analysis

The switch is the fundamental building block of the LAN. This supports connectivity between the end user device and the network. We have 1,015 purpose built switches in service today and 553 will be end of life by 2020. We do not foresee this changing in the immediate future. After a detailed review of current market services and technology offerings, we concluded we will need to replace aging end of life switches with similar devices that support automated configuration and additional security such as network segmentation.

The wireless access point (WAP) is the fundamental building block of the WLAN. This supports connectivity between the end user device and the network via a wireless connection. We have 912 WAPs in service today and 559 WAPs will be end of life by 2021. We primarily use wired LAN connections for IP phone and desktop laptop connectivity supplemented by wireless services where required. However, the needs of the business and users have changed, and now a wireless-first environment is required that provides complete building coverage, capacity that supports three wireless devices per user, and the use of softphone over WLAN replacing desk phones. Due to these requirements, in addition to refreshing ageing access points, the number of access points will need to be expanded. Since this will eliminate the need for WLAN users to wire into the network, this will have the benefit of reducing the number of required LAN switch ports.

The fundamental building block of the voice Infrastructure is the PBX and voice gateway serving all telephony infrastructure. Our plan is to replace the end of life infrastructure to keep services operating as required.

The credible options to deliver this service are evaluated in the table below:

Option	Total cost of ownership	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
Upgrade LAN to high density Wi-Fi (otherwise will need more office space). Replace network assets at EOL with schedule driven by asset refresh policy.	**AMBER** • Does not align with LAN refresh schedule to support switch port reductions. • WLAN charges will increase with additional WAPs. • Migration to an alternate Wi-Fi hardware manufacturer will reduce capex and RTB costs.	**GREEN** • Proven technology from the incumbent network providers. • Adoption of established industry standards, better understood to maintain and expand.	**GREEN** • Supports most of today's business requirements but may not deliver required availability. • Uses established technologies from mature vendors. • Good availability of skills and knowledge internally to exploit.	**AMBER** • Addresses the problem with Wi-Fi and the need to support collaboration, flexible work styles and office hoteling. • Asset refresh schedule will not meet need for improved services. • Wi-Fi is a more complex environment and lack of network redesign, automation and Wi-Fi management tools could result in	**AMBER** • Removes risks around EOL infrastructure in the NG environment. • Proven Technology from incumbent network providers. • Supports most short-term business requirements. • Introduces operational risk of large-scale Wi-Fi environment without proper management tools.	**Rejected** • Provides Wi-Fi capability, but does not address potential cost increases of operating both a fully wired and wireless LAN. • Does not take advantage of potential cost reductions from a LAN redesign e.g. capex savings with alternate hardware, opex reductions through automation and process

Option	Total cost of ownership	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
				increased outages.		improvement.
Upgrade LAN to high density Wi-Fi (otherwise will need more office space). Replace network assets at EOL with schedule driven by asset refresh policy. LAN redesign to reduce RTB over five years	**GREEN** • Reduction in switch ports will reduce LAN costs. • Automation of LAN provisioning will reduce support costs and restoration time. • Implementing management and performance tools will identify issues and reduce outages. • Migration to an alternate Wi-Fi hardware manufacturer will reduce	**GREEN** • Proven technology from incumbent network providers. • Adoption of established industry standards, better understood to maintain and expand.	**GREEN** • Delivers a supportable environment to meet business requirements. • Improves the time to deliver services. • Uses established technologies from mature vendors. • Good availability of skills and knowledge internally to exploit.	**AMBER** • Addresses business need to deliver a high performing Wi-Fi environment to support collaboration, flexible work styles and office hoteling. • Five-year schedule delays the benefit of the network redesign. • Delivers the required improvements to the LAN and associated management tools to	**GREEN** • Removes risks around EOL infrastructure. • Proven technology from incumbent network providers. • Supports most business requirements.	**Recommended** • Provides a fully supported LAN/ Wi-Fi environment with the proper design and operational tools and processes. • Five-year time frame allows for assets to depreciate but delays the delivery of service and cost benefits.

Option	Total cost of ownership	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
	capex and opex run costs.			support the environment.		
Upgrade LAN to high density Wi-Fi (otherwise will need more office space). Replace network assets at EOL with schedule driven by asset refresh policy. LAN redesign to reduce RTB over three years.	**RED** • Replaces assets before they are fully depreciated. • Reduction in switch ports will reduce LAN costs. • Automation of LAN provision will reduce support costs and restoration time. • Implementation of management and performance tools will identify issues and reduce outages. • Migration to an alternate Wi-Fi hardware	**GREEN** • Proven technology from incumbent network providers. • Adoption of established industry standards, better understood to maintain and expand.	**GREEN** • Delivers a supportable environment capable of meeting business requirements. • Improves the time to deliver services. • Uses established technologies from mature vendors. • Good availability of skills and knowledge internally to exploit.	**GREEN** • Addresses business need for high performing Wi-Fi to support collaboration, flexible work and office hoteling. • Three-year schedule better meets the need of the business and opportunities for savings. • Delivers the required improvement to the LAN and	**GREEN** • Removes risks around EOL infrastructure. • Proven technology from incumbent network providers. • Supports most near-term business requirements. • Introduces operational risk of large-scale Wi-Fi environment without proper management tools.	**Rejected** • Replaces assets before they are fully depreciated. • Provides a fully supported LAN/ Wi-Fi environment with the proper design and operational tools and processes. • Three-year schedule better meets the need of the business and opportunities for savings.

Option	Total cost of ownership	Capacity to deliver	Business / strategic fit	Addressing the problem	Risk	Overall
	manufacturer will reduce capex and opex run costs.			associated management tools to support the environment		

Figure 105 – table examines the options available for the enterprise local area and Wi-Fi network

The first option is rejected because while it addresses the need for Wi-Fi, it uses a legacy wired LAN infrastructure that needs to be redesigned to deliver automation and improved and proactive management capability.

The second and third options are technically identical, delivering a redesigned LAN that delivers improved uptime using proactive monitoring and performance tools. In addition, this solution will include provisioning and support automation allowing us to change process and reduce operating costs. While option two delays the delivery of benefits, it is a more responsible approach given its alignment with both the delivery of SD-WAN and the depreciation of LAN assets.

11.5. Detailed analysis and cost benefit analysis

We are continuing to develop our IT investment justification including development of cost benefit analysis.

Aligned with the information above, the preferred WAN option (option two) is to implement software-defined WAN (SDWAN) across all sites supported by private and public network connectivity with local internet breakout.

This option will:

- Enable the rapid adoption of cloud technologies.
- Support the implementation of modern workspace.
- Enhance the cyber security of our networks.
- Ensure efficient operation of network services.

The preferred LAN option (Option two) is to implement a redesigned local area network over five years that supports automation and monitoring and provides high-density Wi-Fi that supports real-time data, voice and video services.

This option will:

- Enable the migration to soft phones and cloud-based telephony.
- Support the implementation of a modern workspace.
- Support flexible workspace and user collaboration
- Enhance the cyber security of our networks.
- Ensure efficient operation of network services.

11.6. Key assumptions, risks and contingency

- We assume the current engineering and safety constraints will continue throughout the RIIO-3 period.
- Costs and options are based on current available technical solutions. The availability of new or disruptive technology may provide additional technical alternatives at the time of implementation.
- We assume all IT projects are progressed and funded; removal of one or more may impact the options analysis and cost assumptions for the remaining deliverables.
- There is a risk/opportunity that the level of coordination between enterprise network refresh and other IT projects will vary from the levels assumed. Where possible, we will coordinate projects to deliver efficiencies. with a resultant impact to cost.

- The primary contingency built into these proposals is additional configuration complexity, increased bandwidth provision, or additional access points.

11.7. Conclusion

The enterprise network is a critical business service that underpins the safe and reliable operation of our business. After a detailed review of current market services and technology we concluded that a network refresh to ensure the secure operation of the services is essential to the health of the business, and our needs could best be met through a network refresh that implements an SD-WAN environment with user LAN access provided by a redesign LAN with WLAN access at all our locations.

Key operating constraints limiting other options are:

- Cloud access is limited by MPLS and centralised internet gateway sizing constraints.
- Wired LAN environments do not support user mobility and collaborative working.
- Limited opportunities for cost reductions using current network architecture without replacing existing devices.

Key operating benefits of the selected options are:

- Local internet circuits provide direct access to cloud apps and an alternative route to corporate applications.
- Local internet reduces the need to increase MPLS and internet gateway bandwidth.
- Local WAN and internet services provide greater resilience.
- Performance-based routing provides additional control over application performance.
- Using generic computing devices to provide the routing function reduces vendor hardware dependency and potentially supports additional capabilities (e.g. local firewall).
- Allows sites to be active more quickly using broadband internet or LTE service.

The implementation of the enterprise network refresh will be phased across the RIIO-2 regulatory period due to the scale and complexity associated with deploying the architecture across our business. The pace of migration is controlled by the installation of the circuits, routing hardware, LAN switches and wireless access points. The LAN and WLAN upgrades are independent from the WAN upgrades, but we will seek out opportunities for joint site access to limit user impact and to realise delivery efficiencies.

12. Appendix A: IT investments

For ease of reference, the following table lists investments by their numerical identifier to easily show the theme it supports and the RIIO-2 investment (totex £ million).

ID	Title	Theme	2021/22	2022/23	2023/24	2024/25	2025/26	Total
110	Network control	1	3.3	5.8	7.3	8.8	5.0	30.0
120	Interconnectors	1	1.7	1.7	0.8	0.8	0.6	5.5
130	Emergent technology and system mgt.	1	0.0	1.7	1.9	2.1	2.1	7.7
140	ENCC operator console	1	0.0	0.8	0.6	1.9	2.2	5.5
150	Operational awareness and decision support	1	0.5	1.9	3.8	4.3	1.9	12.3
170	Frequency visibility	1	0.6	0.6	0.2	0.2	0.2	1.8
180	Enhanced balancing capability	1	9.0	11.3	13.5	6.8	4.5	45.0
190	Workforce and change mgt. tools	1	0.0	0.4	0.8	1.2	1.6	4.0
200	Future training simulator and tools	1	0.0	0.0	1.5	2.9	2.9	7.3
210	Balancing asset health	1	1.4	1.4	1.4	0.0	0.0	4.3
220	Data and analytics platform	1	3.8	7.3	7.3	3.8	2.7	25.0
240	ENCC asset health	1	2.9	2.9	2.9	2.9	2.9	14.6
250	Digital engagement	Data	2.1	2.1	1.8	1.1	0.0	7.0
260	Forecasting enhancements	1	0.0	0.5	0.0	0.5	2.3	3.3
270	EU regulation	2	10.0	8.0	8.0	8.5	8.5	43.0
280	GB regulation	2	3.0	3.0	3.0	3.0	3.0	15.0

ID	Title	Theme	2021/22	2022/23	2023/24	2024/25	2025/26	Total
290	Charging and billing asset health	2	3.0	0.0	0.0	0.0	2.1	5.1
300	Charging regime and CUSC changes	2	1.3	0.8	0.8	0.8	0.8	4.5
320	EMR and CfD Improvements	2	2.1	1.4	1.4	1.4	1.4	7.8
330	Digitalised code management	2	0.0	0.0	0.5	1.3	0.8	2.6
340	RDP implementation and extension	4	3.3	3.5	3.5	6.0	11.0	27.3
350	Planning and outage data exchange	4	0.5	0.5	1.5	1.8	1.8	6.0
360	Offline network modelling	4	1.5	1.0	1.0	2.5	1.0	7.0
380	Connections platform	4	1.2	1.2	0.3	0.2	0.2	3.0
390	*NOA* enhancements	3	3.8	3.8	4.0	2.0	1.5	15.1
400	Single markets platform	2	5.2	5.2	3.6	2.1	2.2	18.3
410	Ancillary services settlements refresh	2	3.5	0.3	0.3	0.3	0.3	4.7
420	Auction capability	2	4.0	2.0	2.0	0.0	0.0	8.0
450	Future innovation productionisation	1	1.0	1.0	2.0	2.0	3.0	9.0
460	Restoration	1	1.0	2.0	7.0	7.0	6.0	23.0
480	Ancillary services dispatch	1	2.5	2.0	0.5	0.0	0.0	5.0
500	Zero carbon operability	4	4.4	5.8	7.8	4.4	2.5	24.9
510	Restoration decision support	1	0.0	0.5	1.5	2.0	1.0	5.0
	Total		**76.5**	**80.3**	**92.4**	**82.4**	**75.8**	**407.3**

13. Appendix B: High level roadmaps

Our roadmaps can be viewed at a platform level – insights and data; digital experience, channels, and engagement; engineering systems; and shared foundations. The high-level roadmaps are shown below.

Insights and data

Our data platform has interdependencies with almost all other investments. It is the foundation for all information provision and decision transparency.

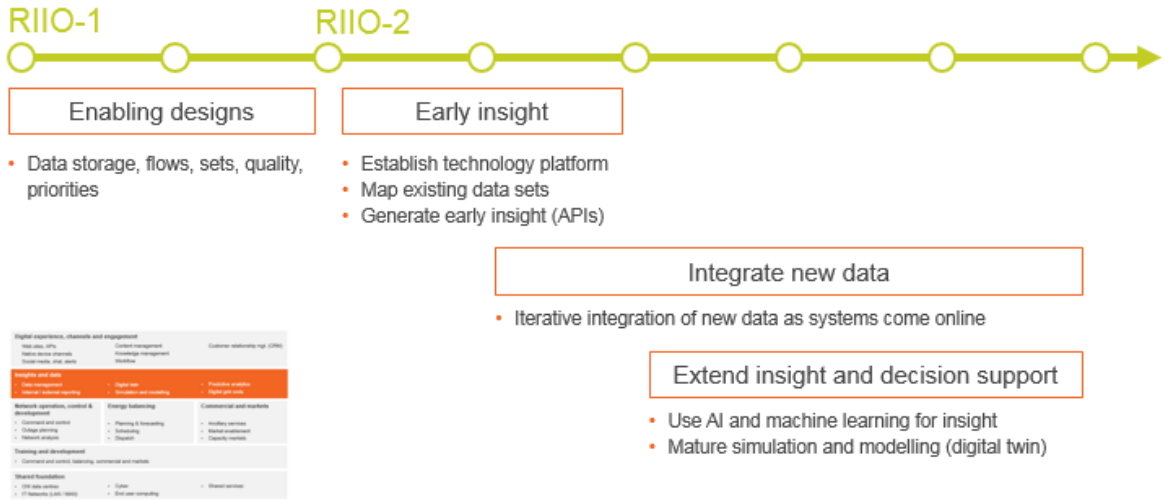

Figure 106 – Insights and data high-level roadmap

Digital experience, channels and engagement

Our digital platform enables both the data and market platforms to be accessed. It provides an engaging user experience and reduces the barrier to engagement.

Figure 107 – Digital experience, channels, and engagement high-level roadmap

Engineering systems

Our engineering systems for network operation and energy balancing will be transformed in parallel to live operations so they are ready for the energy market of the future.

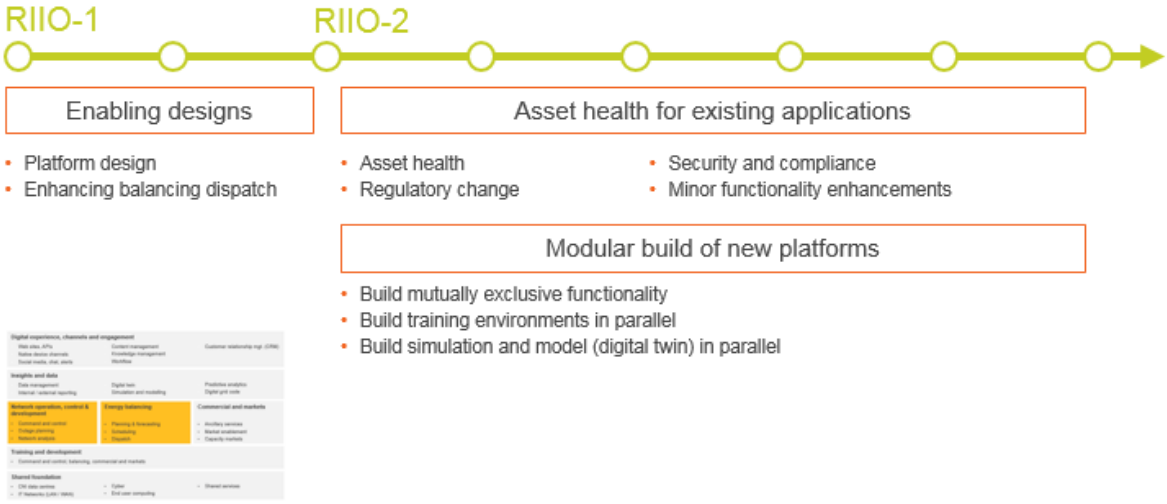

Figure 108 – Engineering systems high-level roadmap

Shared foundations

We cannot achieve any of these technical advances and the related business ambitions without investment in our shared foundation.

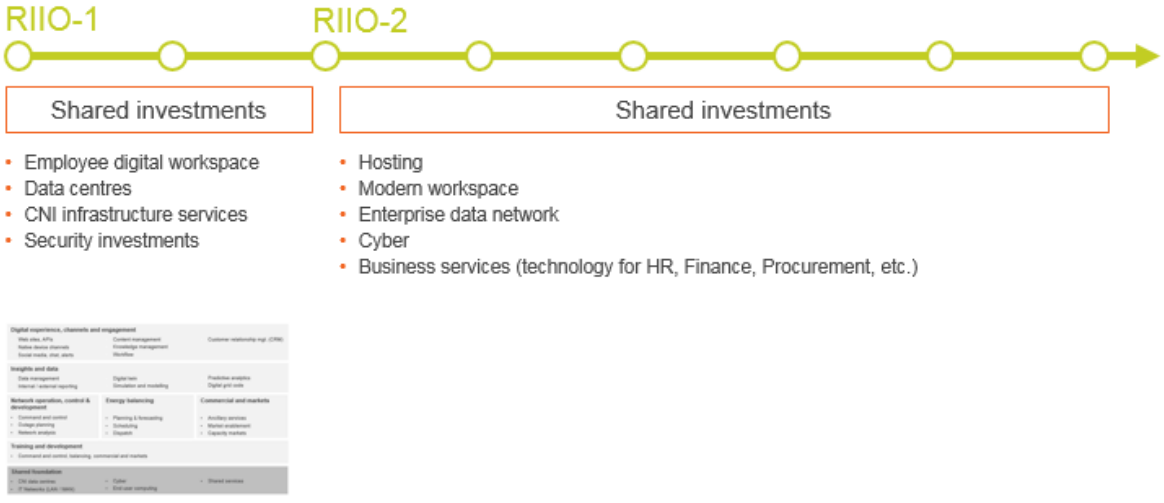

Figure 109 – Shared investments high-level roadmap

14. Appendix C: Portfolio risks

Investments have been costed using a P50 rough order of magnitude estimate. The P50 estimate is the value at which there is a 50 per cent chance of the project coming in above this cost and a 50 per cent chance of it coming in below this cost. This means that no specific contingencies have been built in to our business plan.

We have identified a number of portfolio level risks that apply to many/all investment lines. To avoid repetition, they are listed below.

Risks that apply a single investment are captured in the description for that investment.

The scoring mechanism for both portfolio and individual investment risks is shown below. Impact scores in these risks are based on potential impact to portfolio delivery costs and do not reflect impact on benefit losses.

Risks with a blank impact score have no effect on portfolio delivery costs.

Likelihood

Score	Description	Frequency of occurrence	Probability of occurrence
1	Remote	<Once in 20 years	<20% chance
2	Less likely	<Once in 15 years	>20% & <40% chance
3	Equally likely as unlikely	<Once in 10 years	>40% & <60% chance
4	More likely	<Once in 5 years	>60% & <80% chance
5	Almost certain	One or more a year	>80%& <100% chance
6	Certain		100% chance

Impact

Score	£ million
1	Less than 5
2	Between 5 and 10
3	Between 10 and 30
4	Between 30 and 50
5	Greater than 50

Figure 110 – Risk scoring mechanism.

Risk	Mitigation	Likelihood	Impact
New regulatory changes and changes to existing regulatory commitments are incompatible with our business plan or lead to different priorities (e.g. we are mandated to implement a major EU regulatory change, such as changes to Imbalance Settlement Period or Gate Closure time, or automatic Frequency Restoration	• Ensure regulatory team understands business plan and can align any new regulatory changes to it, supporting the necessary enabling investments for our future business plan. • The full end-to-end process is overseen by the design authority, ensuring market	3	5

Risk	Mitigation	Likelihood	Impact
Reserves or we have to change our plans due to BREXIT like events). Impact: may lead to additional costs to implement major regulatory changes; may prevent us from delivering planned investments (thus reducing benefits of new tools and increasing costs or inefficiencies as we continue to use legacy systems). This may lead us to use Ofgem's proposed cost trigger mechanism.	changes are aligned to business plan. • Have close coordination with European and GB regulator. • Work closely with Ofgem to understand and respond to their intentions.		
Scope of business plan may change (increase or decrease) as more is known (e.g. new operational or cyber security non-functional requirements, changes to market arrangements, different rates of decarbonisation and decentralisation). Impact: Increase or decrease of implementation costs, increase or decrease of run the business costs.	Ongoing review and engagement with stakeholders to ensure business plan integrity and prioritisation.	3	4
Poor data availability or quality (internal or external) or delays in agreeing industry standards impacts on project delivery. Impact: this would require higher costs to implement data validation and cleansing tools and could affect project delivery times and quality due to time consuming discussions on data definitions and coordination processes.	• Understand data needs early in project life. • Work with stakeholders, including the Government's Data Task Force, to ensure the ESO has access to relevant data. • Engage with other European System Operators to ensure consistent operating regimes and reliability standards implementation across Europe as well as availability of consistent data sources or modelling. • Data strategies to be considered in RIIO-1 to ensure	3	3

Risk	Mitigation	Likelihood	Impact
	we understand the necessary data requirements (quality criteria) to enable an effective transition into RIIO-2. • Have data stewards and a data centric culture supported by data management tools in data and analytics platform. • Engage closely with the business and monitor development of the whole system approach. • Utilise the design authority to develop industry consensus.		
RIIO-2 deliverables are delayed (e.g. due to RIIO-1 investments don't finish on time or don't achieve their objectives; mobilisation to deliver RIIO-2 takes longer; interdependencies between projects are of higher complexity nature; supplier or external industry entities delays). Impact: would lead to reprioritisation of RIIO-2 plan, would delay RIIO-2 planned investments leading to spending more money on legacy tools.	• Closely monitor RIIO-1 plans. • Progress future operating model conversations in 2019/20 with a view of implementing the necessary structures/processes and tools to ensure effective transition into RIIO-2. • Map dependencies via a portfolio plan with associated roadmap and actively manage them. • Establish effective framework agreements utilising specialist vendors where appropriate. • Starting our work as soon as possible, in particularly creating the cross-sector design authority, and ensuring we work with them to ensure we are agile and flexible. We have existing established partners and have already started engaging externally with them.	1	4
We are unable to source (for both business and/or IT) the right resource skills and quantity (via internal or external means) to match delivery demand as per the RIIO-2 plan.	• Build resource capabilities as described in the Business Plan chapter 14, People, culture and capability which includes skills required to support all initiatives.	2	n/a

Risk	Mitigation	Likelihood	Impact
Impact: Slower pace of implementation or reduced quality of implementation and benefit loss.	• Start early engagement with HR team, head-hunter, recruitment companies.		
Workings of agreed funding mechanism affect implementation plan. Impact: leads to re-planning of investments and change in delivery timescales.	Close coordination with Ofgem to understand impacts of funding mechanism.	3	n/a
Private versus public cloud solution usage assumptions may change as we mature our requirements and designs. Impact: no impact to totex but would impact categorisation of spend between capex and opex and its phasing.	Review business plan as designs are developed.	3	n/a

15. Appendix D: Lessons learned

We continue to evolve our approach to technology delivery based on lessons learned from RIIO-1 and the increasing pace of change in the industry. These have been grouped into the following categories.

Figure 111 - Key categories of lessons learned

Engagement

- Provide greater transparency in our communications with customers and stakeholders.
- This will be achieved through the introduction of the IT change forum and the establishment the design authority.

Technical design

- Move from siloed applications with point-to-point interfaces to a modular, platform-based architecture that delivers multiple services and supports greater adoption of agile methodologies.
- We will create higher levels of consistency in the user experience.

Sourcing approach

- Utilising third party expertise where necessary.
- New contracts with application development and maintenance partners.

Commercial focus

- Strengthened commercial team.
- Dedicated account managers for each delivery partner.
- Contracting for component delivery in preference to end-to-end project delivery.

Delivery approach

- Greater adoption of agile methodologies such as the Scaled Agile Framework (SAFe) to minimise big bang projects and deliver value incrementally, allowing for scope changes and flexibility to accommodate more rapid market changes.
- Developing the role of the product owner within the business. This will maximise the value of the product that results from the work of the development teams.

Delivery capability

- Building in-house technical capability across aspects of the IT delivery lifecycle.
- Implementing a product-based approach, creating release teams that will enable continuous delivery and release of solutions.

Continuous improvement

- As we provide greater transparency in our communications with customers and stakeholders through the IT change forum and design authority, we will integrate feedback into our deliverables and ways of working.

16. Appendix E: Investment dependencies

This diagram shows the interdependencies between investments that directly support the ESO ambition. In practice, many of these will run in parrallel rather than consecutively as the chart could imply. It is intended to show the interconnected nature of the investments rather than a time bound roadmap.

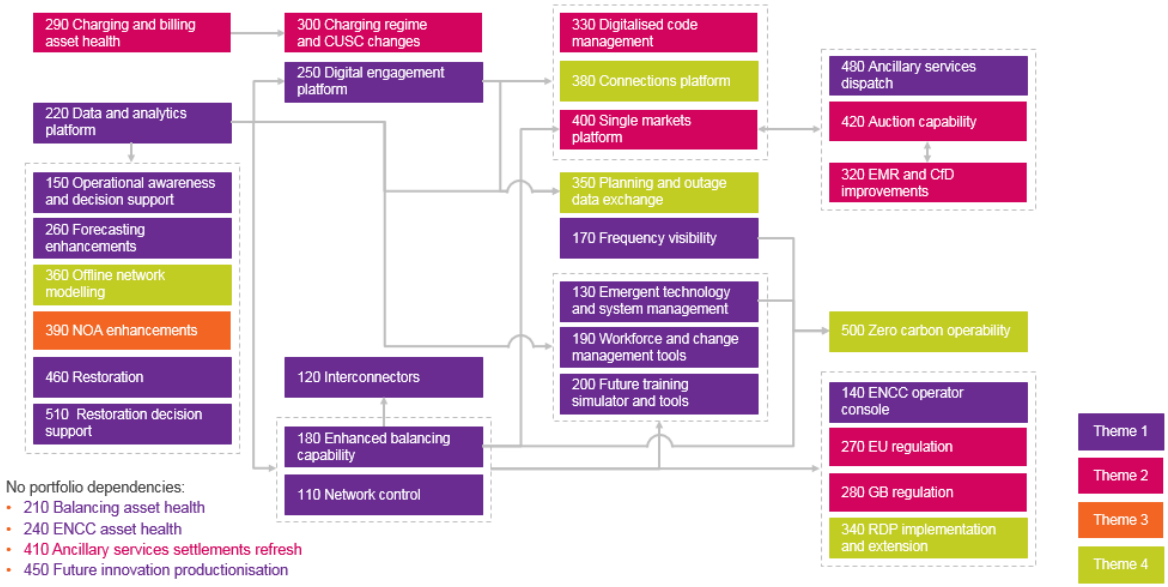

Figure 112 - investment dependencies

17. Appendix F: Investment to activity mapping

The following tables show the mapping between the RIIO-2 activity and technology investments.

Theme 1 – Reliable and secure system operation

Key
Supporting investment to deliver this ambition
Critical investment to deliver this ambition

				110 - Network control	120 - Interconnectors	130 - Emergent technology and system mgt.	140 - ENCC operator console	150 - Op. awareness and decision support	170 - Frequency visibility	180 - Enhanced balancing capability	190 - Workforce and change mgt. tools	200 - Future training simulator and tools	210 - Balancing asset health	220 - Data and analytics platform	240 - ENCC asset health	250 - Digital engagement	260 - Forecasting enhancements	270 - EU regulation	280 - GB regulation	290 - Charging and billing asset health	300 - Charging regime and CUSC changes	320 - EMR and CfD Improvements	330 - Digitalised code management	340 - RDP implementation and extension	350 - Planning and outage data exchange	360 - Offline network modelling	380 - Connections portal	390 - NOA enhancements	400 - Markets platform	410 - Ancillary services settlements refresh	420 - Auction capability	450 - Future innovation productionisation	460 - Restoration	480 - Ancillary services dispatch	500 - Zero carbon operability	510 - Restoration decision support
Reliable and secure system operation	Control Centre Architecture and Systems	1	Business As Usual	■	■	■	■	■	■	■			■	■	■		■															■		■
		2	Transform Network Control	■		■	■	■		■		■		■									■										■	
		3	Control Centre Architecture	■						■				■		■																		
		4	Enhanced Balancing Capability	■	■	■	■	■		■		■		■									■									■	■	
	Restoration	5	Restoration	■						■		■		■									■								■		■	■
	Control Centre Training and Simulation	6	Workforce and change management	■						■	■	■		■																				
		7	Training simulation and technology	■						■		■		■																				

Theme 2 – Open and transparent markets

Theme 3 - *NOA* transformational activities

Key
Supporting investment to deliver this ambition
Critical investment to deliver this ambition

				110 - Network control	120 - Interconnectors	130 - Emergent technology and system mgt.	140 - ENCC operator console	150 - Op. awareness and decision support	170 - Frequency visibility	180 - Enhanced balancing capability	190 - Workforce and change mgt. tools	200 - Future training simulator and tools	210 - Balancing asset health	220 - Data and analytics platform	240 - ENCC asset health	250 - Digital engagement	260 - Forecasting enhancements	270 - EU regulation	280 - GB regulation	290 - Charging and billing asset health	300 - Charging regime and CUSC changes	320 - EMR and CfD improvements	330 - Digitalised code management	340 - RDP implementation and extension	350 - Planning and outage data exchange	360 - Offline network modelling	380 - Connections portal	390 - NOA enhancements	400 - Markets platform	410 - Ancillary services settlements refresh	420 - Auction capability	450 - Future innovation productionisation	460 - Restoration	480 - Ancillary services dispatch	500 - Zero carbon operability	510 - Restoration decision support
NOA transformational activities	NOA transformational activities	22	Embed the extensions we are making to the NOA to enable competition between and across technologies.											■											■		■							
		23	Enhance our analytical capabilities to support these activities.											■											■		■							
		24	Extend the NOA approach to end-of-life asset replacement decisions and connections wider works.											■											■		■							
		25	Support decision-making for investment at the distribution level.											■											■		■							
		26	Review of the SQSS																															

Theme 4 - A whole system approach to the energy transition

Key
Supporting investment to deliver this ambition
Critical investment to deliver this ambition

				110 - Network control	120 - Interconnectors	130 - Emergent technology and system mgt.	140 - ENCC operator console	150 - Op. awareness and decision support	170 - Frequency visibility	180 - Enhanced balancing capability	190 - Workforce and change mgt. tools	200 - Future training simulator and tools	210 - Balancing asset health	220 - Data and analytics platform	240 - ENCC asset health	250 - Digital engagement	260 - Forecasting enhancements	270 - EU regulation	280 - GB regulation	290 - Charging and billing asset health	300 - Charging regime and CUSC changes	320 - EMR and CfD Improvements	330 - Digitalised code management	340 - RDP implementation and extension	350 - Planning and outage data exchange	360 - Offline network modelling	380 - Connections portal	390 - NOA enhancements	400 - Markets platform	410 - Ancillary services settlements refresh	420 - Auction capability	450 - Future innovation productionisation	460 - Restoration	480 - Ancillary services dispatch	500 - Zero carbon operability	510 - Restoration decision support
A whole system approach to the energy transition	Leading the debate: providing energy analysis	27	FES: Steps to Net Zero											■														■							
		28	Distribution/Regional FES											■														■							
		29	Consumer champion																																
	Taking a whole electricity system approach to promote zero-carbon operability	30	Transform our capability in modelling and data management											■		■							■	■	■										
		31	Provide technical support to DSO and whole electricity system alignment																																
		32	Deliver an operable zero-carbon system by 2025	■		■	■	■	■	■		■	■	■	■	■	■	■	■				■	■	■				■	■	■	■	■	■	■
		33	Identify future operability needs across the whole energy system																				■								■				
	Taking a whole electricity system approach to connections	34	Taking a whole electricity system approach to connections											■		■				■	■					■									
	Delivering consumer benefits from improved	35	Enhancing the NAP process with TOs													■								■	■										
		36	Working more closely with DNOs and DER to facilitate network access											■		■								■	■										

Smart data driving zero carbon system operation and markets

Key
Supporting investment to deliver this ambition
Critical investment to deliver this ambition

				110 - Network control	120 - Interconnectors	130 - Emergent technology and system mgt.	140 - ENCC operator console	150 - Op. awareness and decision support	170 - Frequency visibility	180 - Enhanced balancing capability	190 - Workforce and change mgt. tools	200 - Future training simulator and tools	210 - Balancing asset health	220 - Data and analytics platform	240 - ENCC asset health	250 - Digital engagement	260 - Forecasting enhancements	270 - EU regulation	280 - GB regulation	290 - Charging and billing asset health	300 - Charging regime and CUSC changes	320 - EMR and CfD Improvements	330 - Digitalised code management	340 - RDP implementation and extension	350 - Planning and outage data exchange	360 - Offline network modelling	380 - Connections portal	390 - NOA enhancements	400 - Markets platform	410 - Ancillary services settlements refresh	420 - Auction capability	450 - Future innovation productionisation	460 - Restoration	480 - Ancillary services dispatch	500 - Zero carbon operability	510 - Restoration decision support
Smart data driving zero carbon system operation and markets	Publish data and increase transparency	20	Develop an ESO portal to share the data that we hold. The portal will use automated raw data feeds which are created with and for both regulated and non-regulated industry players. The ESO will operate this data portal and lead the industry effort in governing the data that is shared.											■		■																			
	Transform our energy forecasting capability	21	Apply machine learning and artificial intelligence to transform our energy forecasting capability. These tools will allow us to manipulate and develop insight from the ever larger and more diverse sources of data that we will need to forecast supply and demand as we transition to a low-carbon and more decentralised energy system.											■			■																		

18. Appendix G: Gartner benchmark report

Gartner is an industry recognised, independent, technology benchmark organisation. We have tested our technology investments with Gartner and their report is found below. Note that all areas of IT investment have been benchmarked with two exceptions – those items that Gartner do not have experience to assess (shown in 'technology underpinning our investment, RIIO-2 investment benchmarking') and 'shared investments: IT operations and tooling', which was developed after the benchmarking process had completed.

A Report for National Grid Plc

RIIO 2 IT Benchmark Annex – ESO

20 November 2019
Engagement: 330055286

Gartner®

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Executive Summary

Introduction

As part of its preparation for the next round of submissions for funding to Ofgem known as RIIO-2, National Grid (NG) worked with Gartner, over a nine-month period from March to November 2019 to:

1. Benchmark its “run the business” cost base, comparing it to organisations of similar size and complexity and highlighting opportunities for improvement;

2. Review and evaluate the planned capital investments to determine the appropriateness, the levels of funding and gaps to emerging technologies Gartner would envisage being considered during the control period; and;

3. Provide the evidential, documented support to Ofgem in support of the submission.

This report has been tailored specifically for ESO.

IT Operational Cost Benchmark

The operational cost benchmark was based on the UK IT budget for the 2018/19 financial year. Some areas of IT spend are “best in class”, but at 3.86%, IT spend as a percentage of revenue is 16% higher than the peer average.

National Grid’s IT landscape is complex, as a reflection of the needs of three operationally distinct businesses that require high resilient, CNI level systems to provide continuity and security of service to consumers.

A mix of proactive end user friendly approaches and complex legacy applications and hosting also drive IT ‘run’ costs that are 1.54% higher than the peer average. In order to realise further ‘run’ savings investment is needed to mitigate the accumulated technical debt.

Service levels are generally more stringent than peers, reflecting the criticality of the services provided by National Grid as a whole. IT infrastructure refreshment policies are mostly in line with what Gartner sees elsewhere, striking a balance between cost and the risk of failure.

IT Investment Assessment

The assessment process was robust, iterative and highly collaborative, involving several workshops and detailed reviews of documentation for each portfolio. Seven distinct plans were reviewed, three covering the common services: Business Services and UK Finance (BS & UKF), Digital Risk and Security Services (DRSS) and IT Infrastructure, plus one for each operating division: ESO, ET, GSO and GTO.

In the case of common services, National Grid proposes an investment of £462.2M, which is within the middle of Gartner’s assessment range (£359.1M-£478.4M) and will be apportioned accordingly across divisions. ESO’s proposed investment of £407.31M is again within range, though in this instance it is towards the higher-end of Gartner’s assessment range (£308.52M-£441.81M). Planned investments are in-line with industry trends.

To deliver change National Grid uses a framework of suppliers. Gartner reviewed the “rate card” and found overall rates for “UK onsite” based resources are 17% below market average, while “offshore” rates are 4% below market average and in the majority of cases the supplier’s rates are below the bottom of the Gartner range. Low cost doesn’t necessarily always mean value, so Gartner would recommend targeting rates in the second quartile.

Introduction

Approach

As part of its preparation for the next round of submissions for funding to Ofgem known as RIIO-2, National Grid (NG) worked with Gartner, over a nine-month period from March to November 2019 to:

1. Benchmark its “run the business” cost base, comparing it to organisations of similar size and complexity and highlighting opportunities for improvement;

2. Review and evaluate the planned capital investments to determine the appropriateness, the levels of funding and gaps to emerging technologies Gartner would envisage being considered during the control period; and;

3. Provide the evidential, documented support to Ofgem in support of the submission.

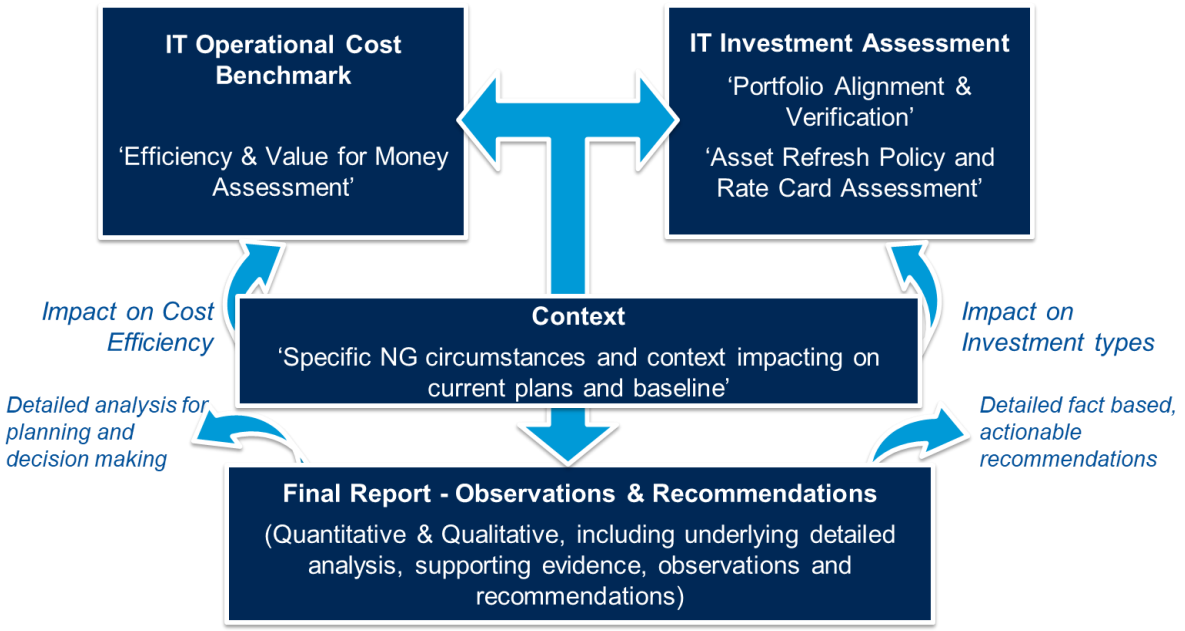


Figure 1: Overall approach

This report summarises the pertinent findings from Gartner’s final report, in a form suitable for inclusion in the Annex of National Grid’s business plan submission to Ofgem.

Scope

Three versions of this report have been written, to support the three distinct business plans NG will be submitting, covering ESO, ET and GSO/GTO. It includes the following sections:

1. IT Operational Cost Benchmark (using 2018/19 as baseline) for the whole IT organisation;

2. IT Investment Assessment for the common IT (i.e. shared) services;

3. IT Investment Assessment for the specific division.

IT Operational Cost Benchmark

Introduction

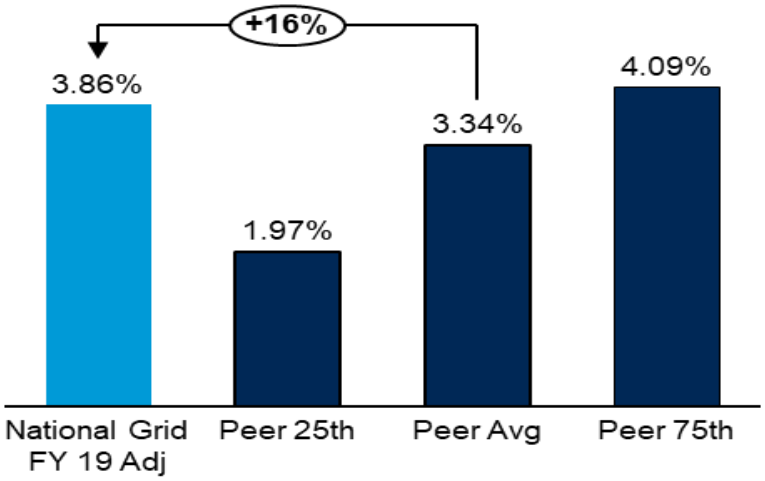
The operational cost benchmark was based on the UK IT (operating and capital) budget for the 2018/19 financial year. The standard Gartner process for Cost Benchmarking is to select two separate and distinct types of peers to fully analyse the efficiency and effectiveness of the IT service. At the enterprise level Gartner select based on comparability within industry; at the technical level peers are selected primarily on supported technology workloads.

Summary

Some areas of IT spend are “best in class”, but overall IT spend is higher than peers, in part as a reflection of the complexity and criticality of the business:

- At 3.86%, IT spend as a percentage of revenue is 16% higher than the peer average.
- Data Centre and WAN costs fall within the “best in class” position for both cost and service, though this masks technical debt and complexity and for the WAN, efficiencies gained by leveraging the Optel network.
- End User Computing and Service Desk are “inefficient” and the proportion spent Applications Support is higher than peers.
- Service levels are generally more stringent than peers, reflecting the criticality of the services provided by National Grid as a whole.
- IT infrastructure asset refreshment policies mostly are in line with what Gartner sees elsewhere, striking a good balance between cost and the risk of failure.

IT Spend as a Percentage of Revenue (%)



National Grid Revenue & IT Spend	Peer Average Revenue & IT Spend	Delta
Revenue:£5.9bn IT Spend: £229.3m	Revenue:£5.9bn IT Spend: £229.3m	+16%

Figure 1: IT Spend as a Percentage of Revenue (%)

Key metrics such as IT spending as a % of revenue are an important tool in understanding the intensity of IT spending within an organisation, however, using them to assess efficiency can be misleading.

In isolation this metric gives the impression of cost inefficiency; however, it does not reflect the specific operational complexities of providing a segregated, highly resilient, CNI level systems on an ongoing basis to three distinct businesses and is susceptible to fluctuations in capital spending cycles. When viewed on a technology basis, National Grid's ongoing costs are more competitive with several areas of efficiency compared with peers and known opportunities for optimisation in others.

IT Spend by Environment

The IT spend has been broken down to different environments or "towers", then compared against selected peers (see Appendix for peer selection methodology):

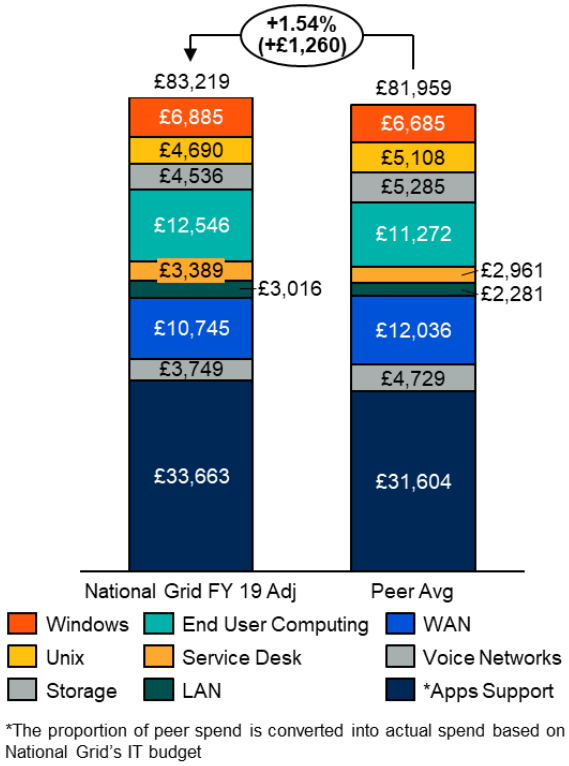


Figure 2: IT Spend by Environment

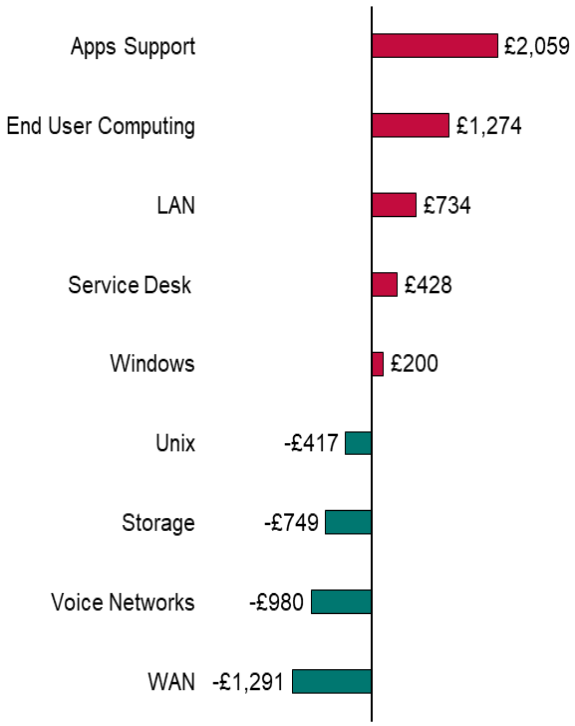


Figure 3: National Grid vs. Peer Average (£000's)

Key observations per tower:

- **Data Centre –** At an overall level National Grid's costs associated with Storage, Unix and Windows and Linux servers all fall within a best-in-class position between the peer average and 25th percentile levels. The ongoing support of legacy platforms on highly depreciated hardware assets are a key factor driving a low-cost position at the expense of the accumulation of technical debt. As the technology continues to age, costly extended support arrangements will be required in order to maintain critical operations unless National Grid continues investment in the transition to commodity cloud ready platforms.

- **Service Desk –** Service desk and end user computing environments lie in an inefficient position between the peer average and 75th percentile levels. National Grid has taken the decision to operate a Tech Bar solution which is typically more expensive, but which drives higher levels of end user satisfaction. As shift left activities continue, National Grid should look to eliminate low complexity contacts through increased automation and self-service functionality, freeing the more expensive tech bar resources for more complex queries.

- **End User Computing** - The requirement to support a large contingent of field services personnel drives a higher ratio of devices to end users than is observed in cross-industry peers which, coupled with a lack of formalized user segmentation or equipment standardisation increases costs. By standardising end user equipment offerings and builds, and by appropriately segmenting end users National Grid should mitigate the additional costs seen compared with peers.

- **Voice Networks –** Traditional voice services lie in a best-in-class position reflecting the commodity nature of the service and a possible shift towards mobile and end user device-based telephony and conferencing services.

- **Local Area Networks –** LAN costs lie in a cost inefficient position between the peer average and peer 75th percentile level. National Grid's wireless first approach facilitates greater flexibility for end users and is a potential driver for increased business productivity. Gartner typically observes that LAN cost efficiencies are found through management of the network rather than the build.

- **Wide Area Networks** - WAN costs represent a higher proportion of overall IT spending than LAN and lie in a best-in-class position between the peer average and 25th percentile levels. This is reflective of the economies gained through the use of Optel infrastructure to support business WAN in addition to CNI/OT capabilities.

- **Applications Support –** National Grid's complex portfolio of applications, including a significant number of unique, business-critical applications unique to the UK energy system, drives a higher proportion of spending on application support activities than peers. Gartner recommends an in-depth workload-based benchmark in order to validate this result. In order to optimise costs in this space Gartner suggests instance consolidation and a thorough review of license usage to eliminate unused licenses.

Asset Refresh Policies

IT infrastructure asset refreshment policies mostly are in line with what Gartner sees elsewhere, striking a good balance between cost and the risk of failure.

Asset type	NG policy	Gartner Min	Gartner Typical	Gartner Max
End user devices	3	2	3.5	5
Network devices	5	5	7	10
Operating systems	5	4	6	10+
Servers	5 – 7	2	4.5	7
Storage	5 – 7	5	7	10+

Figure 4: National Grid refresh policy in years, compared to Gartner research

Service Levels

Gartner reviewed National Grid's service levels across all towers. Service levels are generally more stringent than peers, reflecting the criticality of the services provided by National Grid as a whole, as this example for Windows, Linux and Unix Servers illustrates. Higher service levels usually attract higher costs.

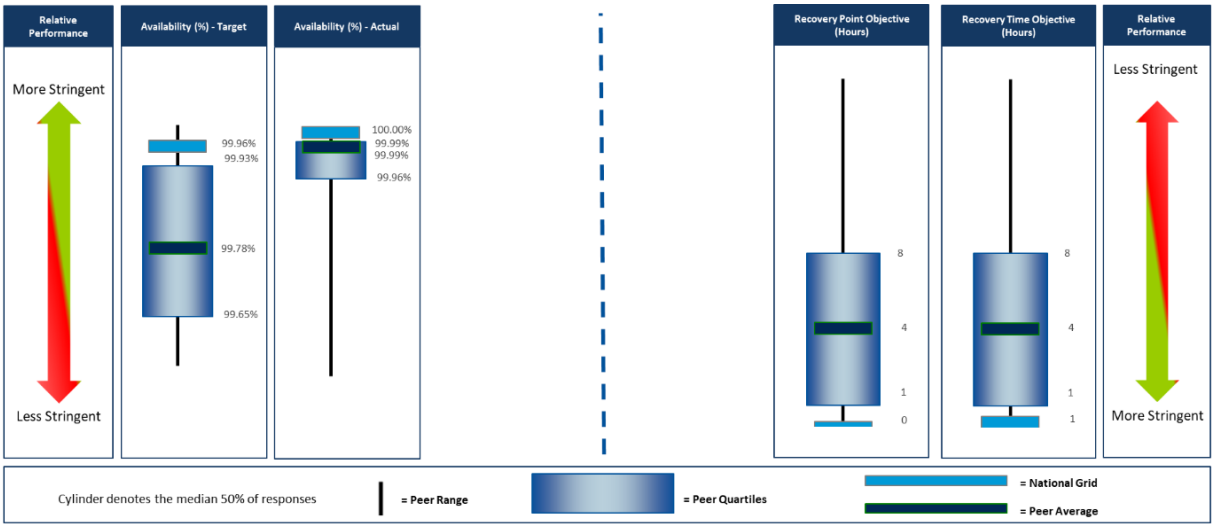


Figure 5: Example SLA target vs. actuals for Windows, Linux and Unix Servers

Conclusion

A mix of proactive end user friendly approaches and complex legacy applications and hosting ultimately drives IT 'run' costs that are 1.54% higher than the peer average. In order to realise further 'run' savings investment is needed to mitigate the accumulated technical debt.

In isolation these metrics give the impression of cost inefficiency; however, it does not reflect the specific operational complexities of providing a segregated, highly resilient, CNI level systems on an ongoing basis, and is susceptible to fluctuations in capital spending cycles. As a result, service levels are generally more stringent than peers, reflecting the criticality of the services provided by National Grid as a whole.

Also, when viewed on a technology basis, National Grid's ongoing costs are more competitive with several areas of efficiency compared with peers and known opportunities for optimisation in others.

IT Investment Assessment

Approach

Over a nine-month period (from March to November 2019) Gartner supported National Grid as it developed its IT investment plan. The assessment process was robust, iterative and highly collaborative, involving several workshops and detailed reviews of documentation for each portfolio.

Seven distinct plans were reviewed, three covering the common services: Business Services and UK Finance (BS & UKF), Digital Risk and Security Services (DRSS) and IT Infrastructure, plus one for each operating division: ESO, ET, GSO and GTO.

Across the whole investment portfolio, several different approaches were taken to benchmarking individual line items, taking comparative data to conduct a verification of what is planned by National Grid in the future, based on what we know today.

Clearly, if National Grid then subsequently does something differently (for example, the scale or scope changes, then the benchmark would prove to be invalid). To give some examples, where National Grid may be doing an asset refresh in the near future, we have a clear and tangible starting point, we know the technology to be refreshed, typically the scale and scope is clear and we have accurate data on the component costs of an upgrade (hardware, software, people costs) based on today's prices.

Similarly, for a new application which may be developed or implemented in the future, we can estimate the size of this based on a large database of project implementations and benchmark against known analogous projects, normalised for the actual estimated size of the National Grid requirement. In both instances, known costs to deliver are used and normalised for scope, the only difference is the prediction of how these costs may vary in the future.

Using a combination of historical trend data and our research analysts predicted future trends, Gartner can model a future cost to National Grid to provide the benchmark and whilst this is an estimate, the materiality of this part is typically very small.

Assumptions

- RIIO2 five-year period is 2021/22 to 2026/27.
- Synergies by delivering like investments across portfolios has not been considered.
- Benchmarked "Totex", made up of both Capex (capital expenditure) and "Project Opex" (operational expenditure that isn't related to "run the business" Opex").
- Operational Technology/CNI (Critical National Infrastructure) investments have been benchmarked were data is available.
- If a benchmark cannot be made (for example, due to a lack of detail or a lack of benchmark data, for example to the unique nature of the investment) then National Grid's anticipated investment is used.
- Investments relating to AI (Artificial Intelligence) and Innovation have been grouped at a portfolio level, reflecting the very uncertain and dynamic nature of such items.
- Gartner has rounded investments to two decimal places, so any minor differences in totals can be explained by this.
- Note that the investments were reviewed at a "point in time" and may not reflect National Grid's final submission.

Cost of change

National Grid delivers change using a number of suppliers, Gartner reviewed National Grid's "rate card" to assess whether rates being provided were competitive. Overall rates for "UK onsite" based resources are 17%, while "offshore" rates are 4% below market average and in the majority of cases the supplier's rates are below the bottom of the Gartner range.

Although very competitive, rates at the lower end of the NG range run the risk of the respective supplier being unable to deliver services and supply capable resources, and still achieve margin, resulting in potential service degradation and relationship risk. While there is no evidence of this at National Grid, Gartner would recommend targeting rates in the second quartile.

Investment portfolio observations

National Grid's overall investment portfolio is in line with what Gartner is seeing elsewhere in the Utilities sector, with a mix of asset health and new initiatives. Key observations:

- 6% of the investment portfolio has been allocated to AI and Innovation related initiatives, in line with recent Gartner utility benchmarks of 3% - 6%.
- 10% has been allocated to Data and Analytics initiatives. This is close to Gartner manufacturing benchmarks (which includes utilities) of 11% - 12%.
- Infrastructure asset policies (as shown above) and planned innovation areas (such as AI, Digital Twins and IoT) are in line with what Gartner is seeing elsewhere (see
- 7% has been allocated to IT Security related initiatives (excluding CNI). Given NG's scope, this compares favourably against Gartner's utilities "Key Metrics" benchmark of 6%.

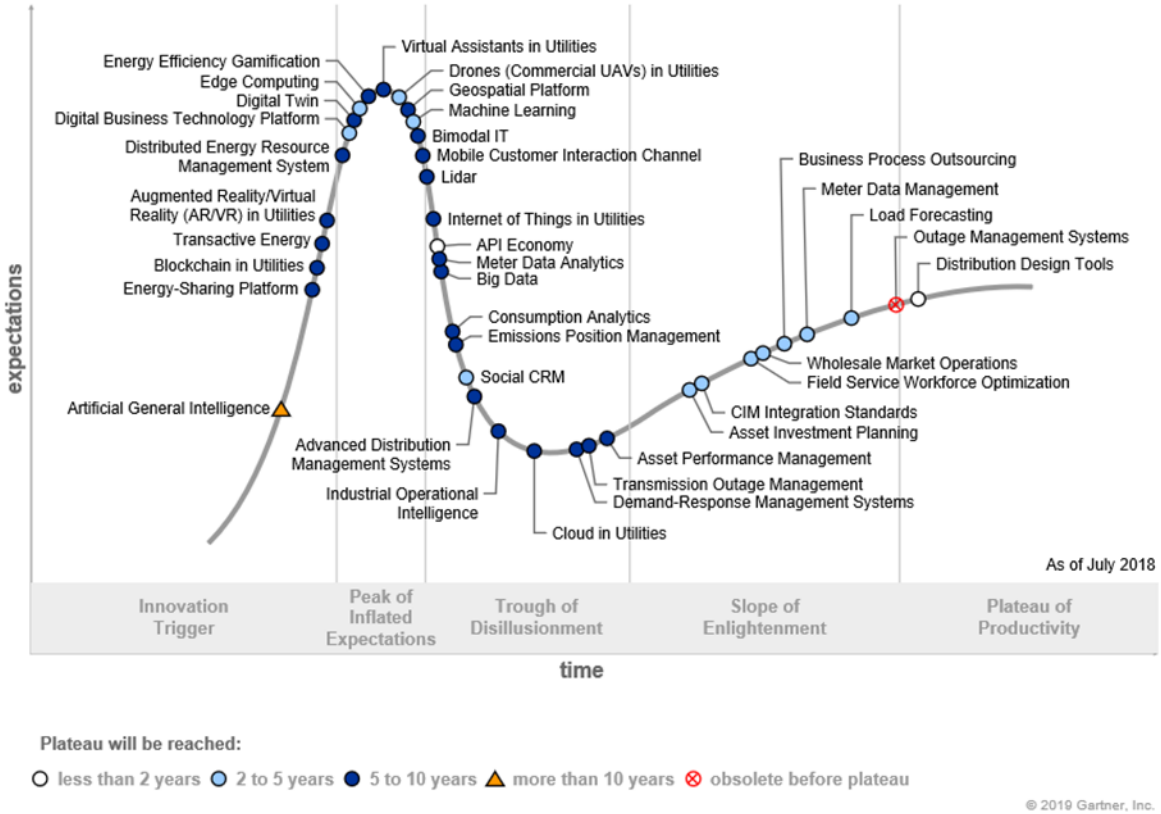


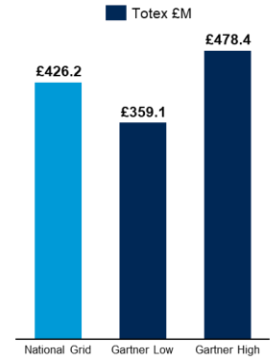
Figure 6: "Hype Cycle" for Utility Industry IT

Common Services

The values listed below represent the total planned investment across National Grid Plc, which will be apportioned accordingly across the divisions. Two complete reviews of the DRSS portfolio were undertaken by Gartner.

All three portfolios were within range and overall the proposed investments were within the middle of Gartner's low and high ranges. Planned investments are in line with industry trends.

Division	Number of initiatives	NG Proposed Investment £M	Gartner "Low" Range £M	Garner "High" Range £M	Observation
BS & UKF	23	108.0	73.1	127.1	Within range
DRSS	11	109.7	101.8	120.0	
Infrastructure	26	208.5	184.2	231.3	
Total	**60**	**426.2**	**359.1**	**478.4**	**Within range**



National Grid's total planned investment, compared to Gartner's assessment

Table 1: Investment Assessment – Common Services Portfolios

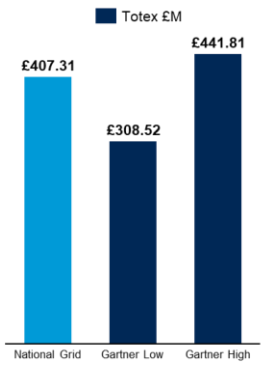
ESO

The investment plan for the Electricity System Operator (ESO) was assessed twice and in isolation of all other portfolios.

The ESO portfolio was within range, though towards the upper end of Gartner's high range.

Planned investments are in line with industry trends.

Division	Number of initiatives	NG Proposed Investment £M	Gartner "Low" Range £M	Garner "High" Range £M	Observation
ESO	33	407.31	308.52	441.81	Within range
Total	**26**	**407.31**	**308.52**	**441.81**	**Within range**



National Grid's total planned investment, compared to Gartner's assessment

Table 2: Investment Assessment – ESO

The breakdown by each individual investment is provided overleaf (in £M).

ID	Initiative	Proposed	Gartner "Lower"	Gartner "Higher"	Variation
110	Network control	30	20	35	
120	Interconnectors	5.5	4.27	5.03	9%
130	Emergent technology and system management	7.7	5	8	
140	ENCC operator console	5.5	2	5.5	
150	Operational awareness and decision support	12.29	15	20	-18%
170	Frequency visibility	1.82	1.6	1.92	
180	Enhanced balancing capability	45	27	44	2%
190	Workflow and change management tools	4	4	6	
200	Future training simulator and tools	7.28	4.03	8.06	
210	Balancing asset health	4.26	1.44	4.5	
220	Data and analytics platform	24.96	23	27.63	
240	ENCC asset health	14.56	14.56	14.56	
250	Digital engagement	7	6.2	11.1	
260	Forecasting enhancements	3.3	1.83	3.67	
270	EU regulation	43	30.09	43	
280	GB regulation	15	10.5	15	
290	Charging and billing asset health	5.08	5	8.33	

ID	Initiative	Proposed	Gartner "Lower"	Gartner "Higher"	Variation
300	Charging regime and CUSC changes	4.45	3.11	3.63	
320	EMR & CFD improvements	7.8	5.46	7.8	
330	Digitalised code management	2.6	1.44	2.88	
340	RDP implementation and extension	27.3	27.3	27.3	
350	Planning and outage data exchange	6	5	6.2	
360	Offline network modelling	7	4.14	12	
380	Connections portal	3	2	5	
390	NOA enhancements	15.1	8	16	
400	Markets platform	18.3	14	20	
410	Ancillary services settlements refresh	4.7	1.6	4.1	11%
420	Ancillary service auction capability	8	4.17	8.33	
450	Future innovation productionisation	9	4.98	9.97	
460	Restoration	23	23	23	
480	Ancillary services dispatch	5	2	4.5	11%
500	Zero carbon operability	24.85	24.85	24.85	
510	Restoration decision support	5	2	5	
	Total	**407.31**	**308.52**	**441.81**	

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