nationalgridESO

# RIIO-2 Business Plan
# Annex 4 - Technology investment report

1 October 2019

# Contents

# 1. Introduction

This annex includes supplementary information on the IT investments directly relating to the ESO and the shared investments made by 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 leverage 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 (£120 million capex, £37 million opex). The full five-year roadmap totals £408 million (£322 million capex, £86 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, don't 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, 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 – improving the investment made under RIIO-1, to enhance our mathematical forecasting models and refresh the system in line with our policies.
- Electricity Market Reform (EMR) and Contracts for Difference (CfD) improvements – here, we will continuously improve user experience based on external feedback or our own experiences.

For all detailed investments, we expect most of the detailed investments to follow an iterative approach, as explained in our strategy - although they appear 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. We could foresee some unexpected changes occurring 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 the appendix.

## 1.2. Shared investments supporting the ESO

The latter sections detail the investment approach to the shared investments.

**A further £103 million over five years (with an initial two-year £55 million) covers ESO's share of group investments.**

ESO's share of group investment at 2018/19 prices is:

- Business services – £16.9 million
- Modern workspace – £8.0 million
- Hosting – £37.2 million
- Enterprise data network – £18.2 million
- Cyber – £22.8 million.

# 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 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, GB 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 so control centre operators can better understand 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 (AI) and a digital twin.

### 2.1.2 Current state

Our integrated electricity management system (IEMS) provides our core network transmission control system. 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 NGET as it enables the safe remote operation of substation equipment, and real-time monitoring of the network, receiving data from the other UK TOs to give a full picture of the UK network.

As part of NGET / ESO split, the dedicated IEMS network and software was updated in RIIO-1 and has also been split so that the NGET can only see the data relevant to their role. An asset health upgrade/replacement will be required in RIIO-2, by 2023.

### 2.1.3 Case for change

Given the legal separation requirements, ESO and NGET will develop their own capabilities in RIIO-2 which may mean this system will no longer be shared.

ESO will not directly receive some network data and signals, so will need different tools to continue to perform its role. These will focus much more on visualisation capabilities and a subset of network alarms.

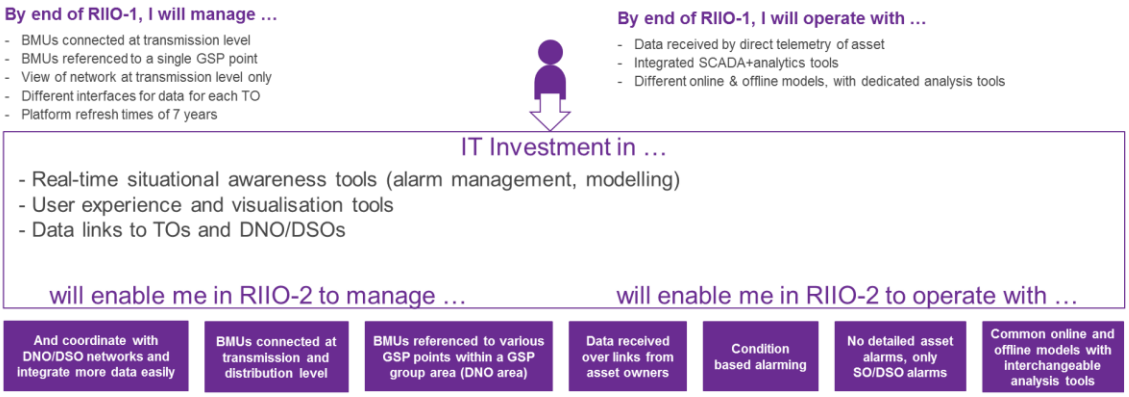


*Figure 1 – Use case, investment and outcome expectation*

### 2.1.4 Roadmap

During the remaining 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.

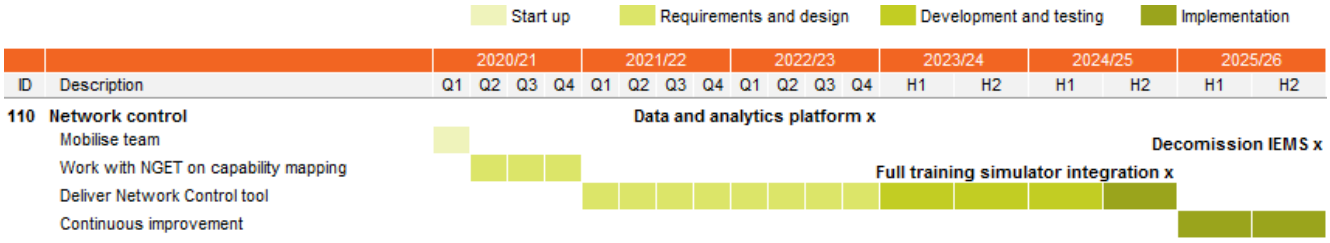


*Figure 2 – Delivery plan*

### 2.1.5 Future state

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

Although not switching or tapping 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 automated network management (ANM) system in DSOs). 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 based on the data and analytics platform and they will be developed to meet the RIIO-2 ambition.

The '220 Data and analytics platform' allows a wide range of application and data integration styles, which will be used to exchange situational data with DSOs, the TSO, and other industry participants.

These methods provide a model of the network in real time and allow combinations of balancing actions to be assessed against the current network state.

AI methods enabled by the artificial intelligence platform will identify (actual and likely) operational incidents from the new operational datasets in RIIO-2. We will use other AI methods to identify the correct remedial or protective action.

In the medium term these integration capabilities will be used to support the current GE electricity management system.

We will outsource much of the development and integration work to our partners.

The primarily cloud-based nature of the 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 | - | 0.1 | 0.2 | 0.4 | 0.6 | **1.3** |

*RTB - run-the-business ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 20.0 |
| High | 35.0 |

### 2.1.8 Options

| Option(s) | Pros | Cons |
|---|---|---|
| Not invest in this area | | • Leaves operational critical tools without support and underperforming.<br>• Increases inefficiencies in our processes and operational actions.<br>• Increases spend on other RIIO-2 invest lines.<br>• Leaves NGET with no support to invest in their tools.<br>• Increases cyber security risk.<br>• Puts at risk 2025 ambition to be able to operate a carbon free electricity system.<br>• Puts 2025 ambition of full competition at risk.<br>• Puts introduction of regulatory changes at risk. |
| Carry on using our legacy tools | | • Doesn't enable economic data share.<br>• Requires refresh of current tools.<br>• Increases RTB risk.<br>• Adds risk of not being able to retain or attract legacy skill resourcing/SME.<br>• Doesn't support investment scalability and flexibility.<br>• Restricts alignment to industry changes.<br>• Increases delivery risk of changes on time and efficiently. |
| Deliver the new capabilities by 2023 aligned with NGET | | • High delivery risk given previous similar projects have taken around five years to deliver.<br>• Puts other prioritised costumer value areas at risk in first years of RIIO-2 plan. |

| Option(s) | Pros | Cons |
|---|---|---|
| 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.<br>• Adds RTB increase until 2025. |
| Deliver the new capabilities by 2025 aligned with NGET | • Meets needs of both ESO and NGET tools.<br>• Simpler data transfer between tools.<br>• Aligns milestones in delivery projects.<br>• Keeps prioritised costumer value areas on their current plan. | |

## 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. These usually require tools for our operational teams to manage these challenges.

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 bringing 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 are only used for limited operational scenarios. Relevant user tools will be integrated with either our enhanced balancing capabilities or network control tool.

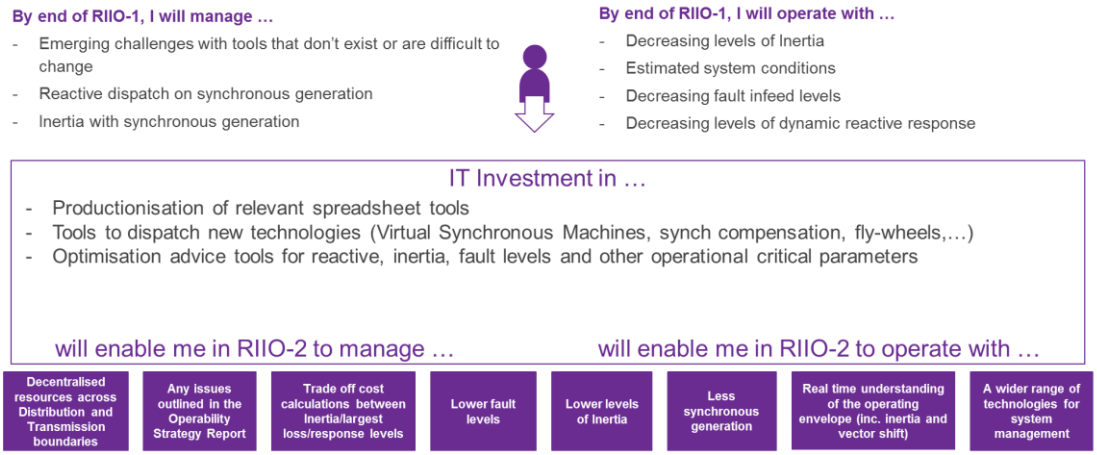


*Figure 3 – Use case, investment and outcome expectation*

### 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 bi-annual 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.

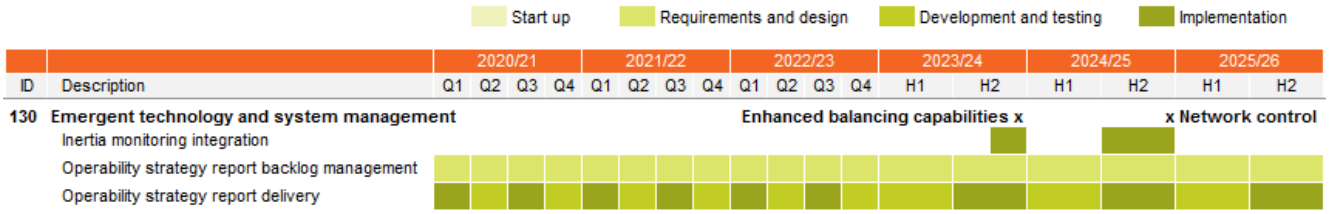


*Figure 4 – Delivery plan*

### 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 all our foundation work, such as the '220 Data and analytics platform', being built on a modular basis like the '180 Enhanced balancing capabilities' to allow its integration with all other tools.

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 the '220 Data and analytics platform' and the '250 Digital engagement platform' allow us to include emergent technologies in the evolving ESO management framework. 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 | - | 1.5 | 1.7 | 1.9 | 1.9 | **6.9** |
| Opex | - | 0.2 | 0.2 | 0.2 | 0.2 | **0.8** |
| **Total** | - | **1.7** | **1.9** | **2.1** | **2.1** | **7.7** |

| | | | | | | |
|---|---|---|---|---|---|---|
| Cumulative RTB* increase | - | - | 0.2 | 0.4 | 0.6 | **1.2** |

*RTB - run-the-business ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 5.0 |
| High | 8.0 |

### 2.2.8 Options

| Option(s) | Pros | Cons |
|---|---|---|
| Not invest in this area | | • Doesn't facilitate new generation technologies or business models to enter the energy markets.<br>• Creates operational risk, staff overheads and technical debt by addressing new operational problems with inefficient processes and workarounds.<br>• Puts at risk 2025 ambition to be able to operate a carbon free electricity system.<br>• Puts 2025 ambition of full competition at risk. |
| Continue with user written tools | | • Creates operational risk, staff overheads and technical debt by addressing new operational problems through inefficient solutions and processes.<br>• Increases cyber security risk.<br>• Increases sustainability risk as it depends on SMEs who wrote tools. |
| Update tools and integrate with data platform, network control and enhanced balancing capabilities | • Increases transparency of operational actions.<br>• Enables easy and efficient data sharing with our customers.<br>• Enables process efficiencies.<br>• Enables better operational decision-making via enhanced data insights.<br>• Supports 2025 ambition to be able to operate a carbon free electricity system.<br>• Permits 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/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.

### 2.3.3 Case for change

Evolving control centre roles and 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 send visualisations from individual screens to the video wall. This means replacing the current video wall with more flexible, cheaper technology. As ESO, we are the only organisation covering the whole of GB 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.

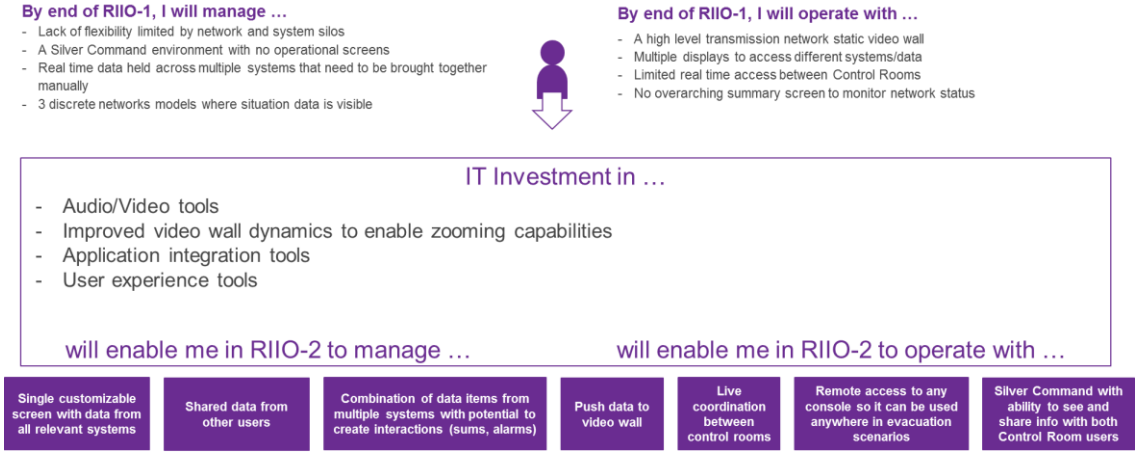


*Figure 5 - Use case, investment and outcome expectation*

### 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 continue to modernise the control centre environment and supporting infrastructure.

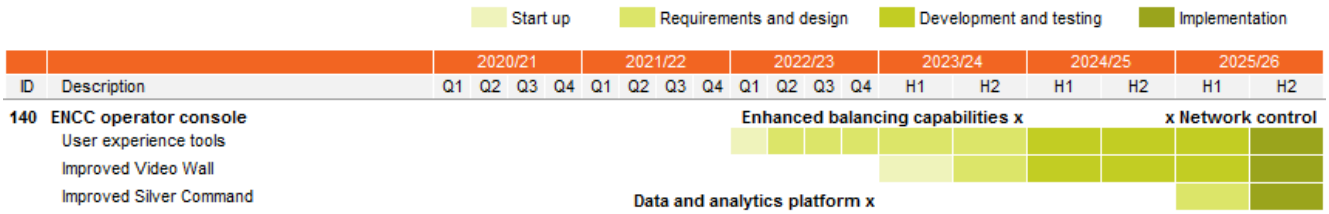


*Figure 6 – Delivery plan*

### 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 to share with other team members or the whole control centre.


*Figure 6 – 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 and, in emergency cases, the silver command team to give the most up-to-date and relevant information to external stakeholders.

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

### 2.3.6 Approach

New application components (e.g. optimisers, network control tools, situational awareness tools, dispatch tools) will be developed with responsive web user interfaces (UIs) that can combine to form large custom UIs. 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 room 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 | - | 0.7 | 0.5 | 1.7 | 2.0 | **5.0** |
| Opex | - | 0.1 | 0.1 | 0.2 | 0.2 | **0.6** |
| **Total** | - | **0.8** | **0.6** | **1.9** | **2.2** | **5.5** |
| | | | | | | |
| Cumulative RTB* increase | - | - | 0.0 | 0.0 | 0.1 | **0.1** |

*RTB - run-the-business ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 2.0 |
| High | 5.5 |

Gartner has based its higher value 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 Options

| Option(s) | Pros | Cons |
|---|---|---|
| Not invest in this area | | • Creates operational risk, staff overheads and technical debt as it addresses visualisation problems with inefficient processes and workarounds.<br>• Introduces performance degradation.<br>• Maintains low user experience.<br>• Increases cyber security risk. |
| Carry on using our legacy tools | | • Creates operational risk, staff overheads and technical debt as it addresses visualisation problems with inefficient solutions and processes.<br>• Maintains low user experience.<br>• Increases operational security risk.<br>• Increases cyber security risk. |
| Update tools and integrate with data platform and enhanced balancing capabilities | • Enables high and consistent user experience.<br>• Enables introduction of efficient processes.<br>• 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 from 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 stand-alone 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 provide decision-making (e.g. machine learning). This investment is also required to enable whole-system simulation and modelling, both online or offline.

As the generation mix moves towards more intermittent sources (e.g. wind, photo-voltaic), the current business process based on an estimate from the previous day will become unreliable and a system security risk.

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

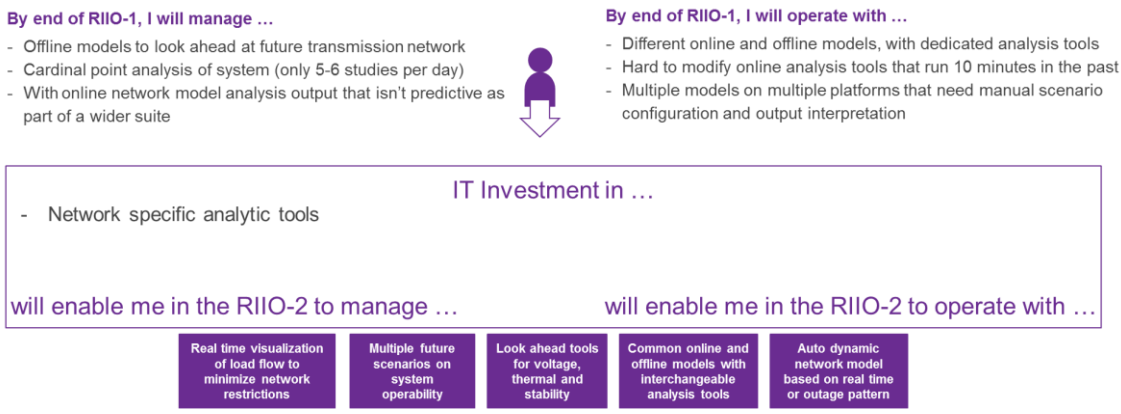


*Figure 7 - Use case, investment and outcome expectation*

### 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 capability.
- Closer to real-time look-ahead power flow capability that builds on the current day ahead congestion forecast (DACF).
- Improved voltage stability assessment as 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.

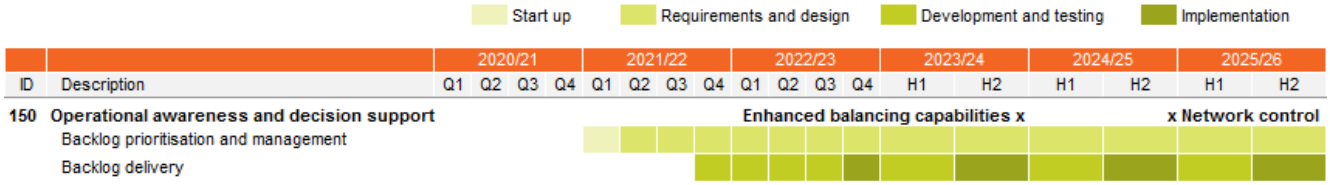


*Figure 8 – Delivery plan*

### 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 and offline tools more efficient control centre operation. These tools will be integrated via the investment under '220 Data and analytics platform' (arrows reflect data flows):

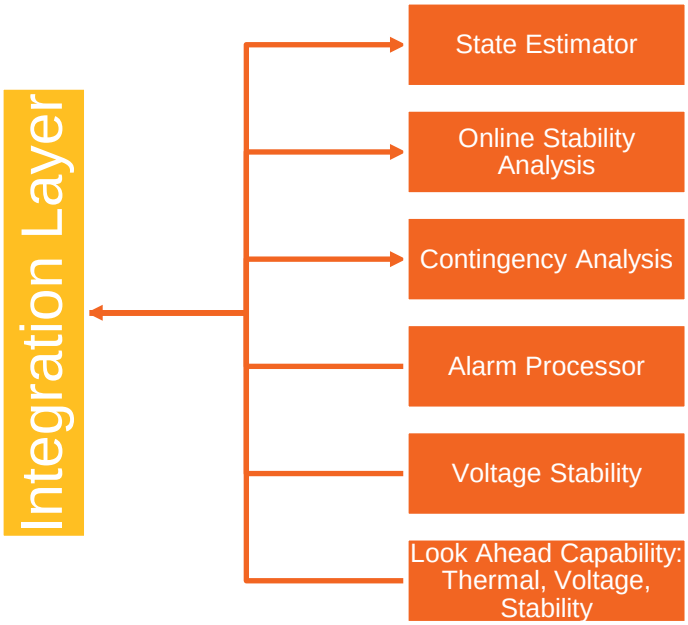


*Figure 9 – Integrated investments*

### 2.4.6 Approach

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

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 the '220 Data and analytics platform' which will be upgraded to meet the needs of the RIIO-2 programme.

AI and the 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 | 0.1 | 0.2 | 0.3 | **0.5** |

*RTB - run-the-business ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 15.0 |
| High | 20.0 |

### 2.4.8 Options

| Option(s) | Pros | Cons |
|---|---|---|
| Not invest in this area | | • Increases operational risk.<br>• Increases cyber security risk.<br>• Puts at risk 2025 ambition to be able to operate a carbon free electricity system.<br>• Increases inefficient decision-making and associated operational costs.<br>• Doesn't enable transparency of operational actions. |
| Carry on using our legacy tools | | • Doesn't enable investment scalability.<br>• Puts at risk 2025 ambition to be able to operate a carbon free electricity system.<br>• Increases the risk that current tools aren't fit for purpose in a changing energy landscape.<br>• Doesn't support transparency of operational actions. |
| Update tools and integrate with data platform, network control and enhanced balancing capabilities | • Supports 2025 ambition to be able to operate a carbon free electricity system.<br>• Ensures tools remain fit for purpose in line with industry changes.<br>• Enables investment scalability.<br>• Enables introduction of efficient processes.<br>• 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 room to manage frequency and inertia and understand the effects of system events on with confidence.

### 2.5.4 Roadmap

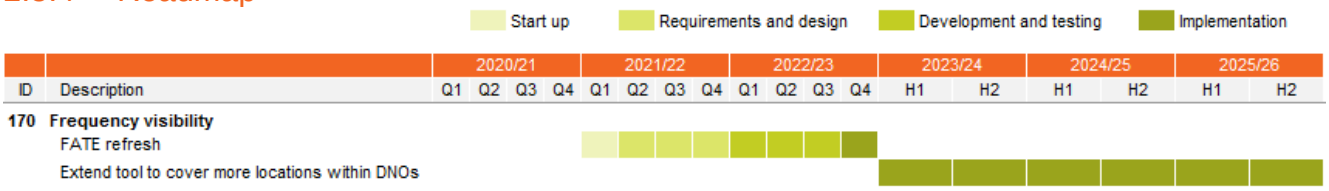


*Figure 10 – Delivery plan*

### 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 the CNI environment to increase its reliability and security.

This investment will also underpin investment in inertia monitoring (‘130 Emergent technology and system management’) and the wide area monitoring and control system (‘500 Zero carbon operability’).

### 2.5.6 Approach

Aside from continuing to extend the FATE system, we will take the same approach as for ‘110 Network control’, etc in using big data and data science techniques to develop the operational views and models we need.

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 applications are supported, integrated and extended by the '220 Data and analytics platform' and will be developed to meet the RIIO-2 ambition.

### 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 | **0.1** |

*RTB - run-the-business ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 1.6 |
| High | 1.9 |

### 2.5.8 Options

| Option(s) | Pros | Cons |
|---|---|---|
| Not invest in this area | | • Puts our capability to manage system frequency at risk.<br>• Increases cyber security risk.<br>• 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.<br>• 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 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 National Grid's Electricity Licence at risk. It is essential that we invest in our core balancing systems to manage the rapidly evolving electricity market.

### 2.6.2 Current state

The core balancing capability is currently provided by a hybrid solution of 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, BM. Most of these systems were designed against a traditional landscape of large transmission connected generation. We assume CLOGS will become part of the core balancing capability and its use no longer needed given investment in dual resilience.

We make around 200 instructions every hour. We expect this to increase to over 2,000 instructions per hour over the next few years due to wider access delivered through project TERRE, discussed in Theme 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:

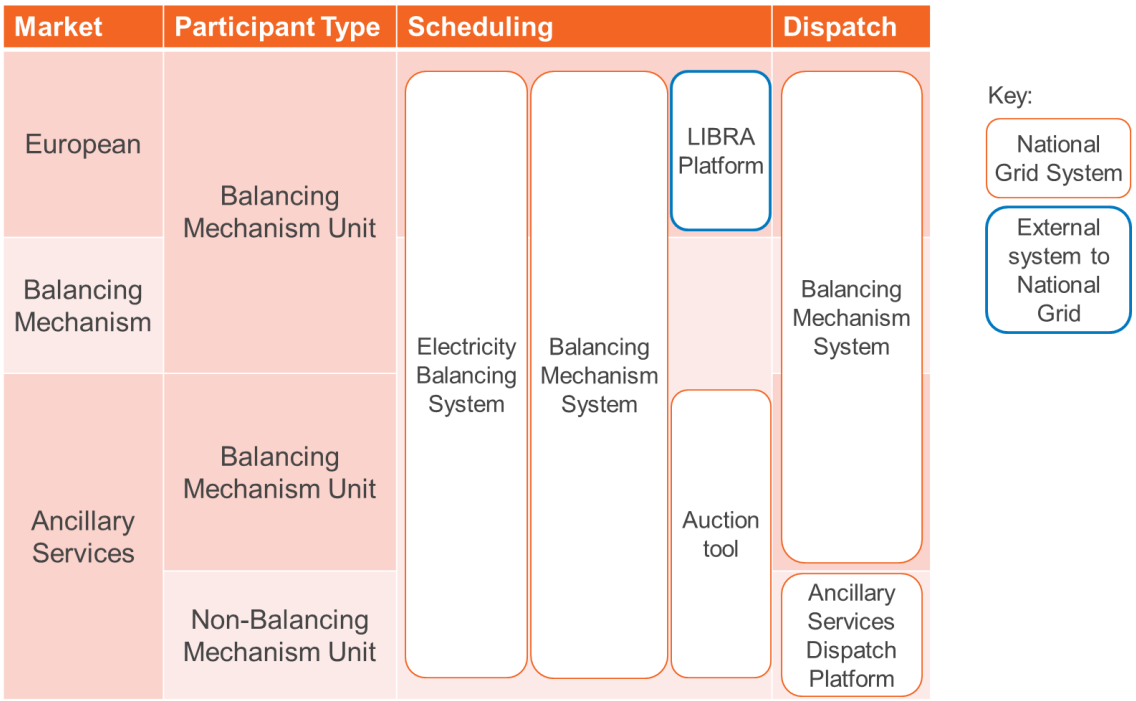


*Figure 11 – Anticipated balancing system landscape*

### 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 a high-level decision process to dispatch one market participant. There are currently around 2,000 BMUs. This 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. So 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.

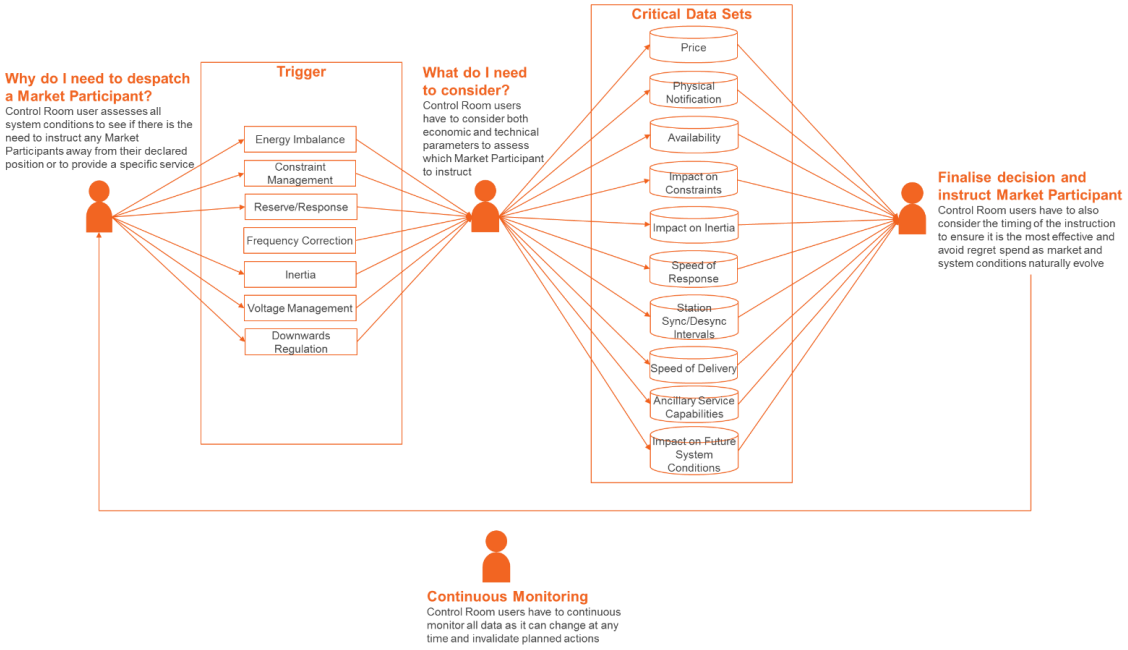


*Figure 12 – High-level decision process for control centre engineers*

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

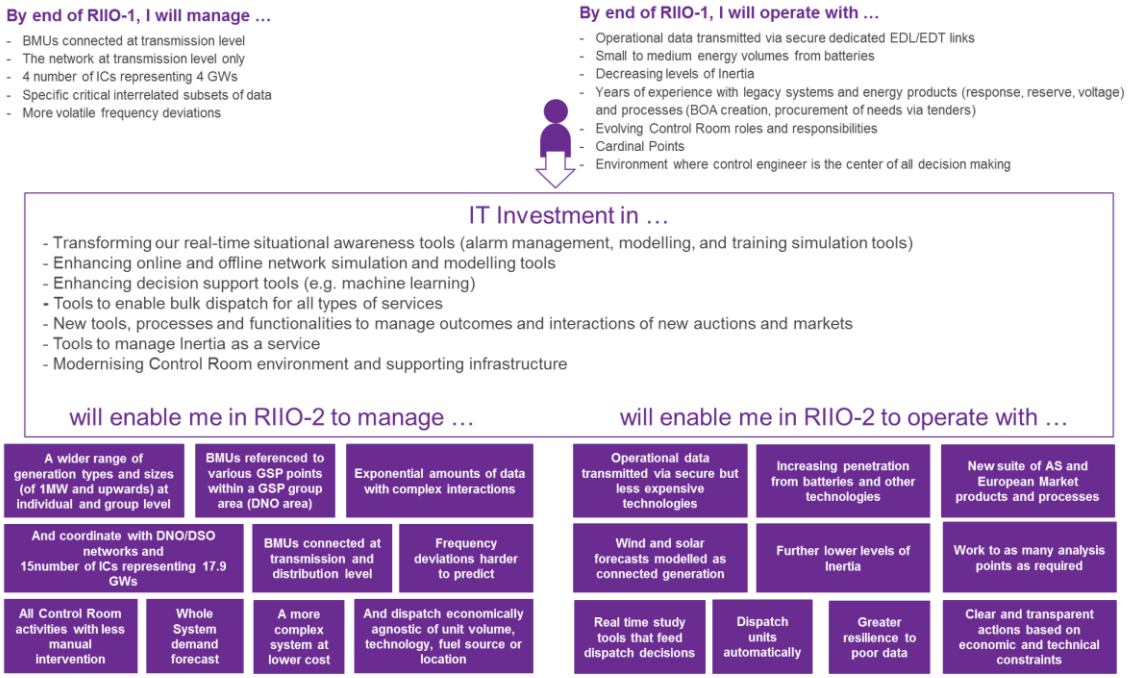


*Figure 13 - Use case, investment and outcome expectation*

## 2.6.4 Roadmap

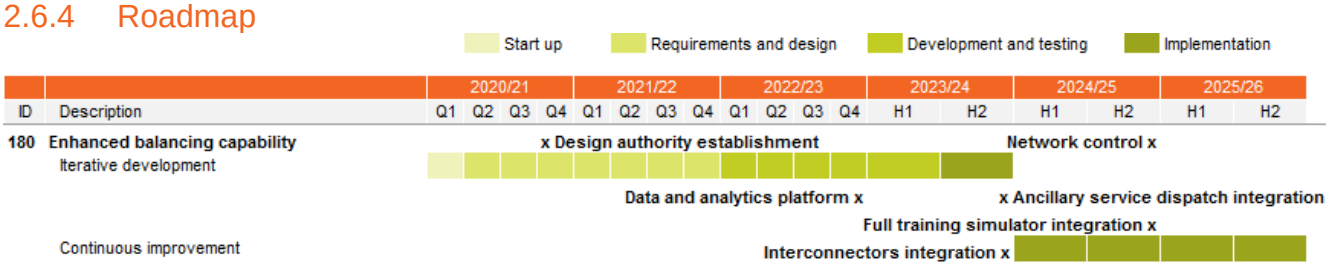


*Figure 14 – Delivery plan*

### 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 will make better use of data by integrating these capabilities with the '220 Data and analytics platform' and apply machine learning and automated control to transform system balancing. This will underpin other investments, like '120 interconnector' management and '130 Emergent technology and system management' and allow us to program 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.

These are our main specific electricity systems and many of their components are bespoke and 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.

### 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. 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 ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 27.0 |
| High | 44.0 |

Gartner's higher value for their range is just under our proposal. Lower and higher value gap is in part 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.

[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.

### 2.6.8 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.<br>• Increases cyber security risk.<br>• Doesn't support transparency of our operational actions.<br>• Doesn't support investment scalability and flexibility.<br>• Puts at risk 2025 ambition to be able to operate a carbon free electricity system.<br>• Puts 2025 ambition of full competition at risk.<br>• Leaves critical tools unsupported.<br>• Puts regulatory changes at risk. |
| Carry on using our legacy tools | | • Requires refresh of current tools.<br>• Doesn't support investment scalability and flexibility.<br>• Restricts pace of change to align to industry changes.<br>• Increases risk of delivering changes timely and efficiently.<br>• Risk of not being able to retain or attract legacy skill resourcing/SME. |
| Update tools and integrate with data platform and network control and markets platform | • Enables introduction of flexible and scalable tools aligned with industry changes.<br>• Supports transparency of our operational actions.<br>• Introduces delivery efficiencies.<br>• Supports easy and economic data sharing with our customers.<br>• Enables 2025 ambition to be able to operate a carbon free electricity system.<br>• Enables 2025 ambition of full competition. | |

## 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 (MODIS), interconnector data exchange (IDX) and the ancillary services (AS) settlements system.

### 2.7.3 Case for change

During RIIO-2 we expect 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.

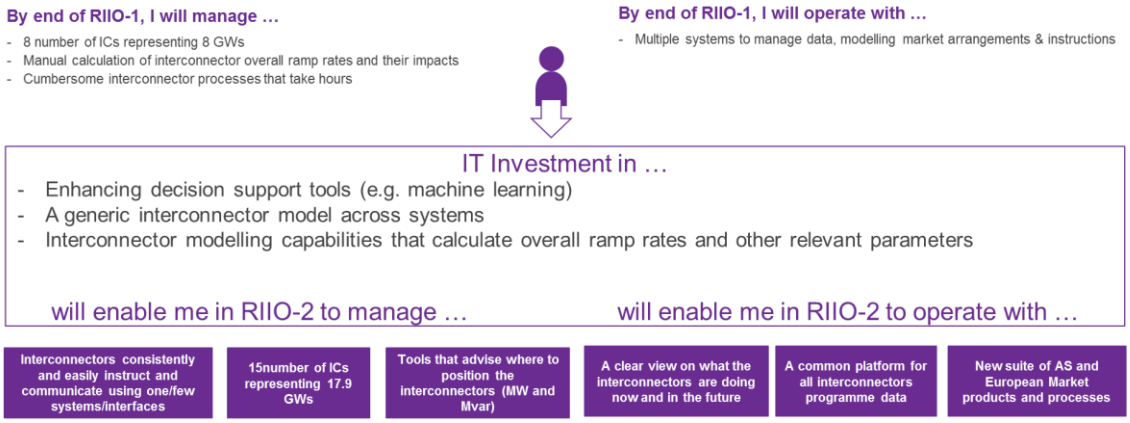


*Figure 15 - Use case, investment and outcome expectation*

### 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.

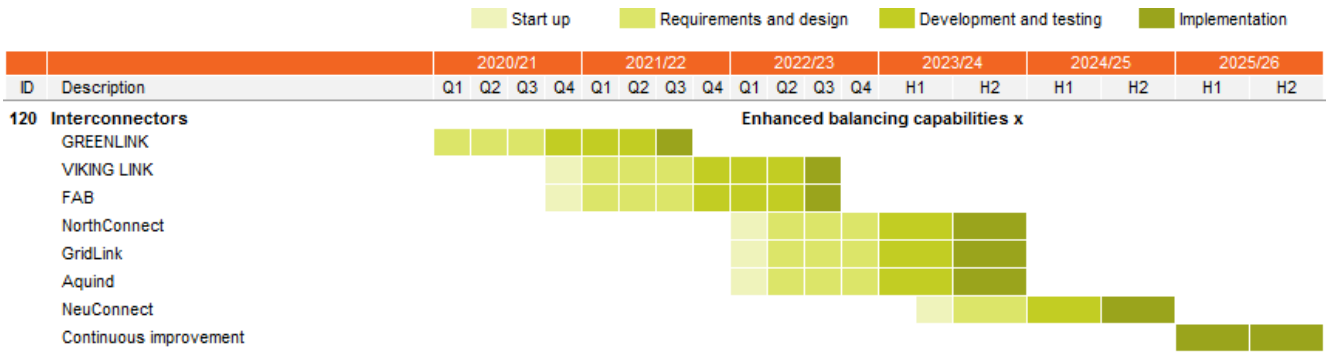


*Figure 16 – Delivery plan*

### 2.7.5 Future state

New interconnectors will become part of our future '180 Enhanced balancing capabilities' 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 and reduce costs of changes for new interconnectors going-live or adding new balancing services.

Improvements will mostly be visible after 2023/24 as benefits of this investment rely on '180 Enhanced balancing capabilities' 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 platforms 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 ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 4.3 |
| High | 5.0 |

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. So, we have left our costs at the present level.

### 2.7.8 Options

| Option(s) | Pros | Cons |
|---|---|---|
| Not invest in this area | | • Doesn't allow for new interconnectors.<br>• Restricts GB and European market benefits.<br>• Puts at risk 2025 ambition to be able to operate a carbon-free electricity system.<br>• Puts 2025 ambition of full competition at risk. |
| Carry on using our legacy tools | | • Continues inefficiency between the enhanced balancing capabilities and the interconnector management legacy systems.<br>• Doesn't facilitate easy or economic data share leading to lack of transparency. |

| Option(s) | Pros | Cons |
|---|---|---|
| | | • Puts at risk 2025 ambition to be able to operate a carbon free electricity system.<br>• Doesn't save time delivering new interconnectors from 2024/25. |
| Update tools and integrate with data platform and enhanced balancing capabilities | • Enables efficient processes.<br>• Enables efficient sharing data with our customers.<br>• Saves time in delivery 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/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 don't 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 risky.

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.

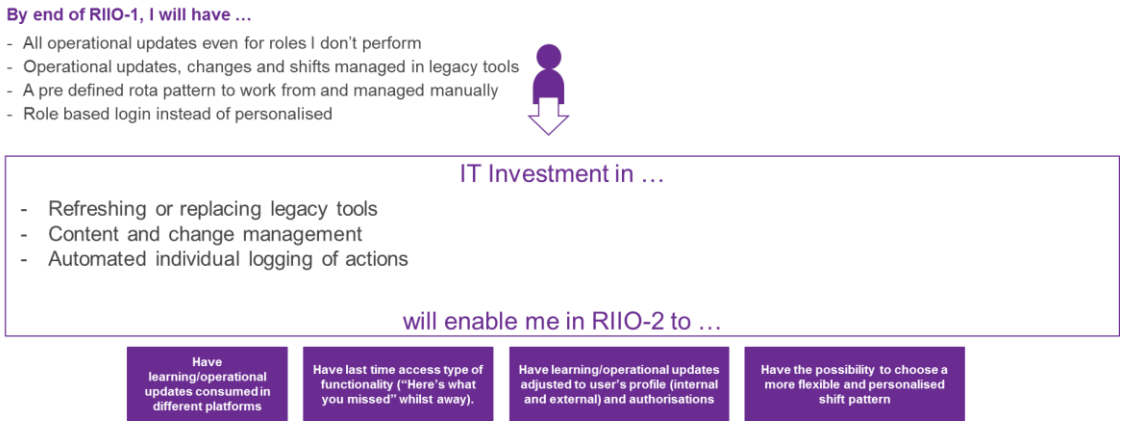


*Figure 17 - Use case, investment and outcome expectation*

## 2.8.4 Roadmap

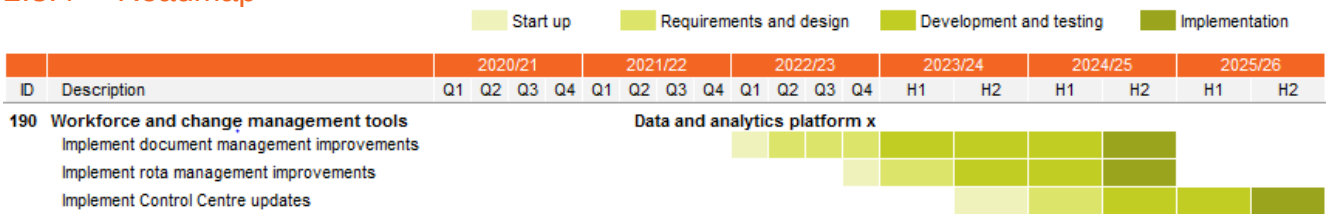


*Figure 18 – Delivery plan*

## 2.8.5 Future state

We will integrate these management tools with our '180 Enhanced balancing capabilities' 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, e.g. 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 (BoB) approach i.e. 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 platforms 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 | - | - | - | - | - | - |
| Opex | - | 0.4 | 0.8 | 1.2 | 1.6 | **4.0** |
| **Total** | - | **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** |

Gartner benchmark range

| | |
|---|---|
| Low | 4.0 |
| High | 6.0 |

*RTB - run-the-business ongoing opex

## 2.8.8 Options

| Option(s) | Pros | Cons |
|---|---|---|
| Not invest in this area | | • Increases risk of not being able to retain or attract skilled workforce.<br>• Prevents efficient development of current workforce.<br>• Introduces operational risk.<br>• Puts at risk 2025 ambition to be able to operate a carbon free electricity system. |
| Carry on using our legacy tools | | • Increases operational risk.<br>• Introduces inefficiencies in our compliance processes.<br>• Prevents efficient development of current workforce.<br>• Doesn't facilitate easy and cost-effective data share with our customers.<br>• 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.<br>• Facilitates transparency of our actions.<br>• Enables flexible and efficient compliance and regulatory processes.<br>• 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.

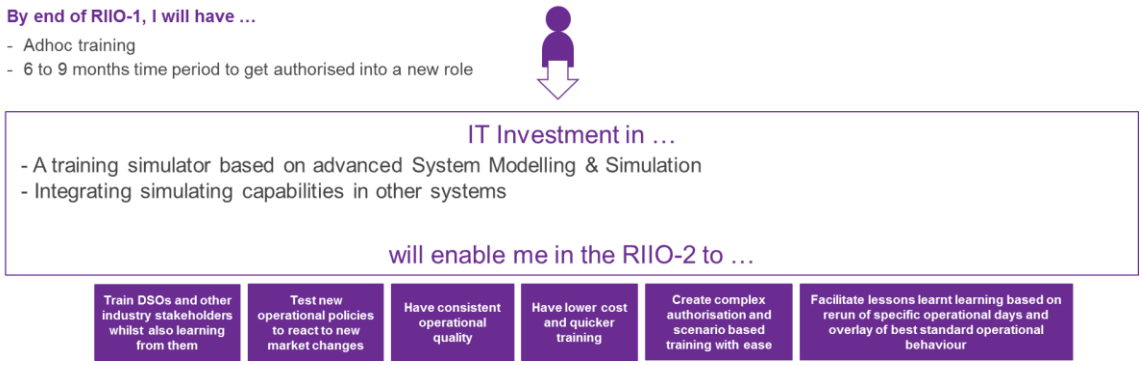


*Figure 19 - Use case, investment and outcome expectation*

## 2.9.4 Roadmap

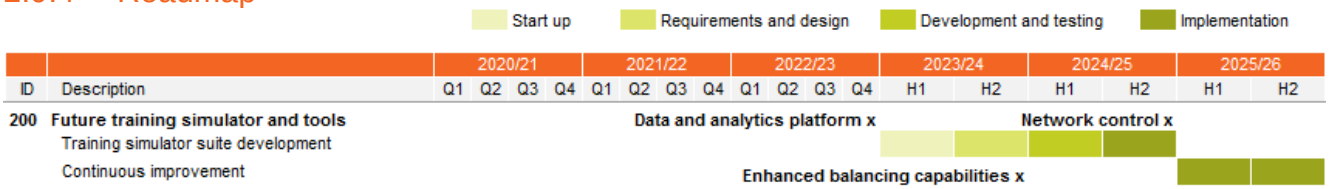


*Figure 20 – Delivery plan*

## 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 the '400 Single markets platform' investment to easily create complex scenarios.

The same capabilities will be used to train DSOs and other industry stakeholders 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 simulate 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 will be cloud native (e.g. the new optimisers) to simplify and lower their cost.

## 2.9.7 Costs

| Investment (£m) | 2021/22 | 2022/23 | 2023/24 | 2024/25 | 2025/26 | Total |
|---|---|---|---|---|---|---|
| Capex | - | - | 1.2 | 2.3 | 2.3 | **5.8** |
| Opex | - | - | 0.3 | 0.6 | 0.6 | **1.5** |
| **Total** | - | - | **1.5** | **2.9** | **2.9** | **7.3** |

| | | | | | | |
|---|---|---|---|---|---|---|
| Cumulative RTB* increase | - | - | - | 0.1 | 0.2 | **0.3** |

Gartner benchmark range

| | |
|---|---|
| Low | 4.0 |
| High | 8.1 |

*RTB - run-the-business ongoing opex

### 2.9.8 Options

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

Cloud-based data management and analytics are now universal and essential for modern data analysis approaches; even more so for AI implementations. This investment will evolve National Grid'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 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 storage that will result from the changing regulatory framework and the increase in market participants.

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

During the RIIO-1, a core set of integration systems has 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.

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

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 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 reporting systems with solutions integrated within a data and analytics platform.

The expected large increase in the number of small distribution connected generators, new emerging technologies and changing consumer behaviour are expected to drive strong growth in the volumes of data. This 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 create a digital twin (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.

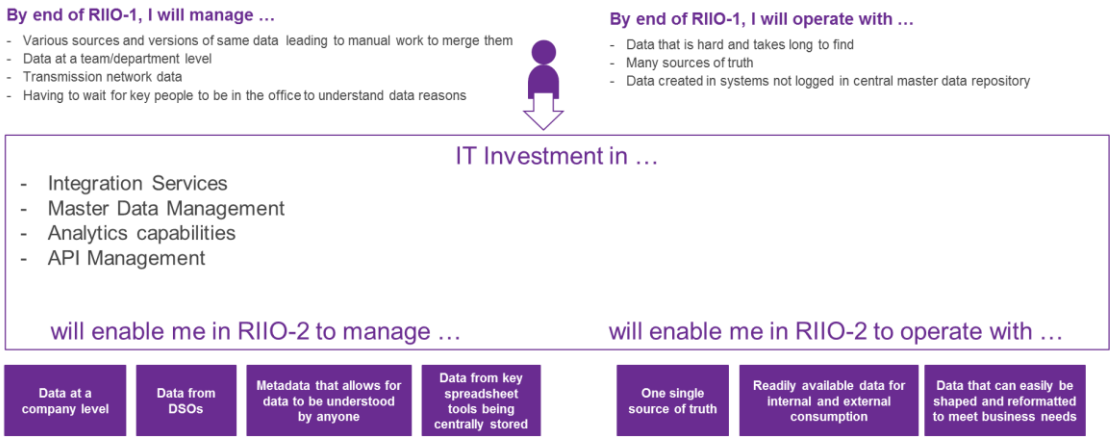


*Figure 21 - Use case, investment and outcome expectation*

### 2.10.4 Roadmap

Our immediate focus in year 1 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 and work done under 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 service-oriented architecture (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.

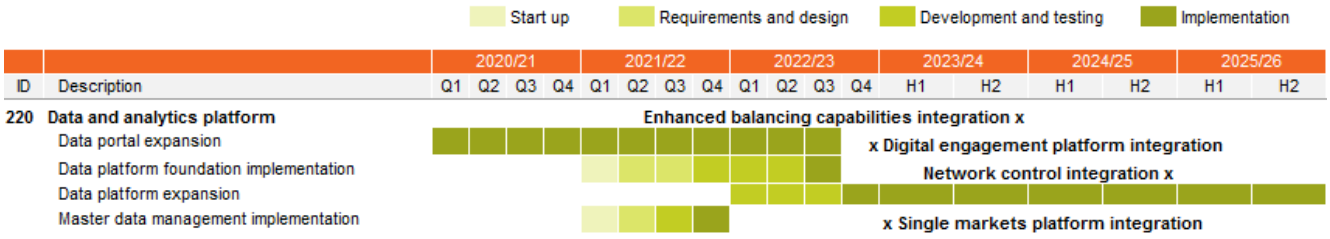


*Figure 22 – Delivery plan*

### 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 overlaid with analytics 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, but 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 service-oriented architecture (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 | - | 0.1 | 0.3 | 0.5 | 0.6 | **1.4** |

Gartner benchmark range

| | |
|---|---|
| Low | 23.0 |
| High | 27.6 |

*RTB - run-the-business ongoing opex

### 2.10.8 Options

| Option(s) | Pros | Cons |
|---|---|---|
| Not invest in this area | | • Prevents easy and economic data sharing with our customers.<br>• Creates operational risk, staff overheads and technical debt as it addresses data problems with inefficient processes and workarounds.<br>• Requires higher level of investment in other areas to make up for data inefficiencies.<br>• Puts at risk other prioritised costumer value areas in RIIO-2 plan.<br>• Puts 2025 ambition of full competition at risk.<br>• Doesn't enable transparency of our actions.<br>• Prevents reacting to new customer data needs in a timely way. |
| Carry on using our legacy tools | | • Doesn't enable easy and economic data sharing with our customers.<br>• Doesn't allow for scalability of investment.<br>• Duplicates investment in other areas to make up for lack of data standards.<br>• Puts at risk other prioritised costumer value areas in RIIO-2 plan.<br>• Puts 2025 ambition of full competition at risk.<br>• Introduces inefficiencies as different standards get used to address data problems.<br>• Doesn't support transparency of our actions. |

| Option(s) | Pros | Cons |
|---|---|---|
| | | • Prevents reacting to and meeting new customer data needs in a timely way. |
| Update tools and integrate with data platform, network control, digital engagement platform and enhanced balancing capabilities | • Enables 2025 ambition of full competition.<br>• Enables transparency of our actions.<br>• Enables easy and economic data-sharing with our customers.<br>• Allows for scalability of investment.<br>• Supports objectives of other prioritised costumer value areas in RIIO-2 plan.<br>• Introduces data standards and efficient management.<br>• 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

Investment to put as 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 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 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 NIA and NIC projects are covered by their own investment lines, included elsewhere in the RIIO-2 submission:

- Productionisation of EFCC is now included under ‘500 Zero Carbon Operability’.

- Productionisation of the FFR auction trial is included under '420 Auction Capability'.
- Productionisation of the Restoration trial is covered under '460 Restoration', and '510 Restoration decision support'.
- Productionisation of Power Potential is covered under '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 2-3 years, any productionisation would not take place until the latter part of the 5-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 | 0.1 | 0.2 | 0.3 | **0.6** |

*RTB - run-the-business ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 5.0 |
| High | 10.0 |

### 2.11.8 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 restoration 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.

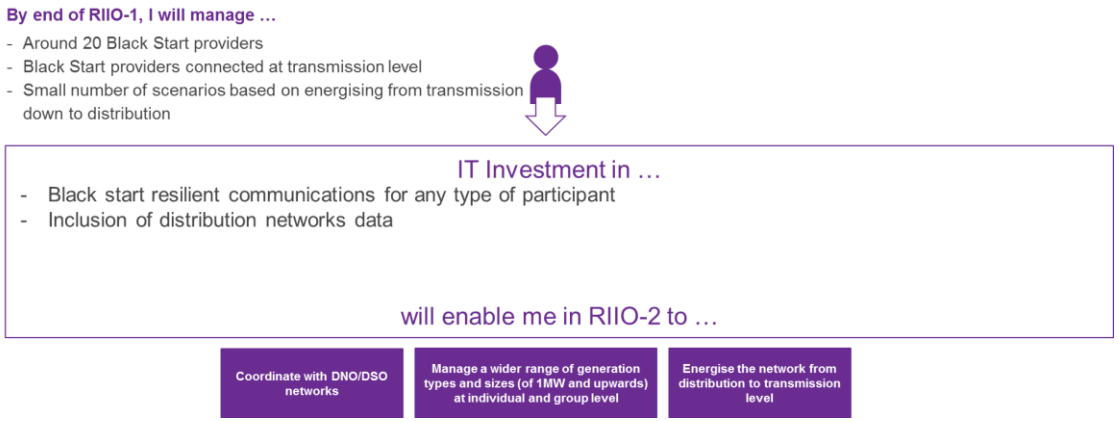


*Figure 23 - Use case, investment and outcome expectation*

### 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.

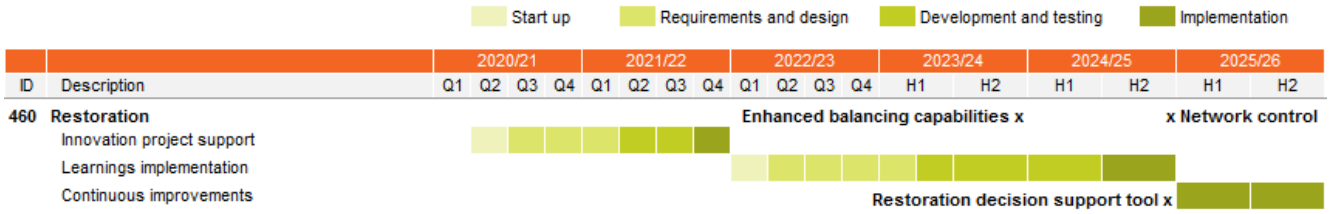


*Figure 24 – Delivery plan*

### 2.12.5 Future state

We will run an innovation project for technological solutions and procurement recommendations. From these, we will put in place changes ranging from secure communication links to 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 TO) 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 | - | 0.1 | 0.3 | 1.1 | 1.9 | **3.4** |

Gartner benchmark range

| | |
|---|---|
| Low | 23.0 |
| High | 23.0 |

*RTB - run-the-business ongoing opex

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.

### 2.12.8 Options

| Option(s) | Pros | Cons |
|---|---|---|
| Not invest in this area | | • Doesn't enable 2025 ambition of full competition.<br>• Puts at risk 2025 ambition to be able to operate a carbon free electricity system.<br>• Prevents introduction of efficiencies in this operational area.<br>• Increases risk of longer restoration periods. |
| Update tools and integrate with data platform and enhanced balancing capabilities | • Enables 2025 ambition of full competition.<br>• Supports 2025 ambition to be able to operate a carbon free electricity system.<br>• Introduces efficiencies in restoration processes.<br>• 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 small 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 due to be issued by the end of RIIO-1. 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.

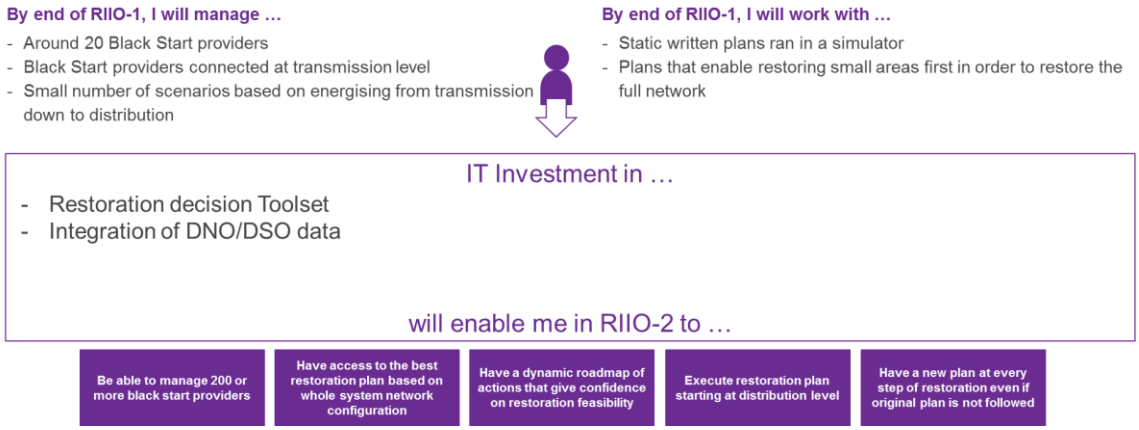


*Figure 25 - Use case, investment and outcome expectation*

### 2.13.4 Roadmap


*Figure 26 – 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.

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 | - | 0.5 | 1.4 | 1.8 | 0.9 | **4.5** |
| Opex | - | 0.1 | 0.2 | 0.2 | 0.1 | **0.5** |
| **Total** | - | **0.5** | **1.5** | **2.0** | **1.0** | **5.0** |

| | | | | | | |
|---|---|---|---|---|---|---|
| Cumulative RTB* increase | - | - | 0.1 | 0.2 | 0.4 | **0.7** |

*RTB - run-the-business ongoing opex

| Gartner benchmark range | |
|---|---|
| Low | 2.0 |
| High | 5.0 |

Our initial proposal was a higher value than the range given by Gartner. Based on Gartner's feedback aligned our proposal to their higher range value.

### 2.13.8 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.<br>• Puts at risk 2025 ambition to be able to operate a carbon free electricity system.<br>• Prevents introduction of efficiencies from innovation project. |
| Carry on using our legacy tools | | • Creates operational risk, staff overheads and technical debt as it addresses restoration problems with inefficient solutions and processes.<br>• Puts at risk 2025 ambition to be able to operate a carbon free electricity system at risk.<br>• Prevents introduction of efficiencies from innovation project. |
| Update tools and integrate with data platform and network control | • Ensures efficient compliance with new restoration standards.<br>• Supports 2025 ambition to be able to operate a carbon free electricity system.<br>• Introduces efficiencies in restoration processes.<br>• Allows introduction of efficiencies from innovation project. | |

# 3. Theme 2 investment lines

## 3.1. 250 Digital engagement platform

Current stage:

| Scoping | Start-up | Requirements and design | Development and testing | Implementation |
|---|---|---|---|---|

### 3.1.1 Overview

This investment, mentioned in the open data chapter, 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.

### 3.1.2 Current state

We started investing in this area during RIIO-1, developing pockets of functionality through CRM (customer relationship management) 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.

### 3.1.3 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 increase our customers' user experience and improve our own productivity in this area. Some potential benefits include:

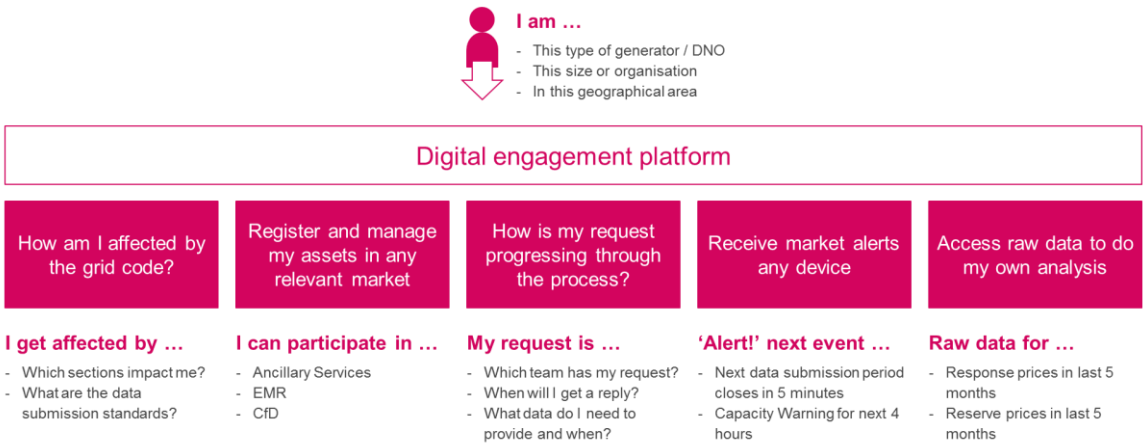


*Figure 27 - Use case, investment and outcome expectation*

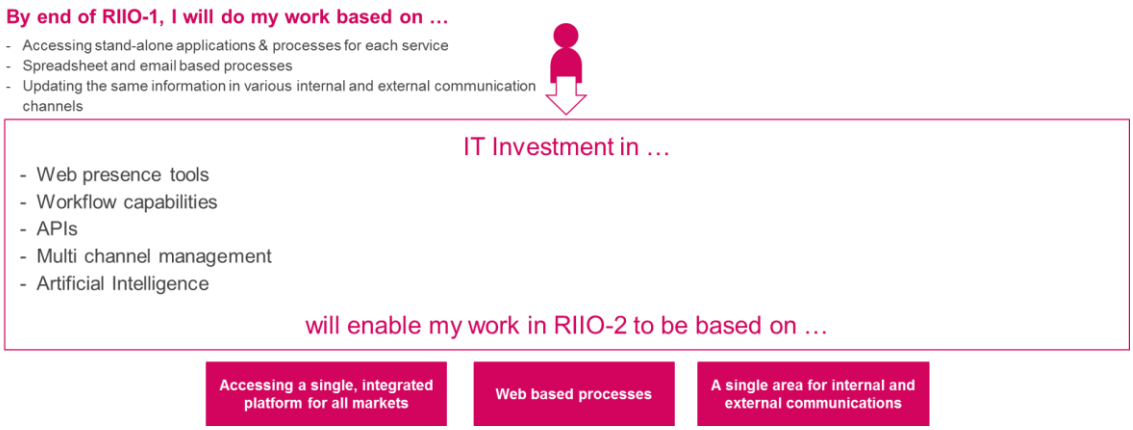


*Figure 28 - Use case, investment and outcome expectation*

### 3.1.4 Roadmap

The data portal investment from RIIO-1 will be integrated with our customer relationship management (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.

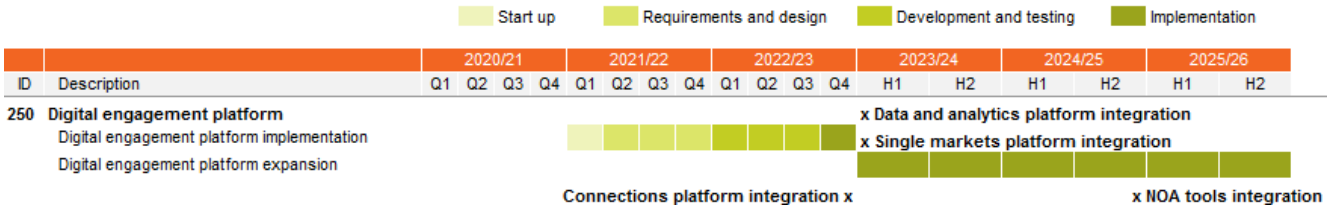


*Figure 29 – Delivery plan*

### 3.1.5 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 application programming interfaces (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 '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 |

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

*Figure 30 – Investment efficiency opportunities*

### 3.1.6 Approach

We will develop a new enterprise 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 service-oriented architecture (SOA) to standardise and automate access for the RIIO-2 business service i.e. in addition to implementing a key component of the ESO SOA, the API Manager tier, the digital engagement platform will be internally service-oriented.

### 3.1.7 Costs

| Investment (£m) | 2021/22 | 2022/23 | 2023/24 | 2024/25 | 2025/26 | Total |
|---|---|---|---|---|---|---|
| Capex | 1.3 | 1.3 | 1.1 | 0.6 | - | **4.2** |
| Opex | 0.8 | 0.8 | 0.7 | 0.4 | - | **2.8** |
| **Total** | **2.1** | **2.1** | **1.8** | **1.1** | - | **7.0** |

| | | | | | | |
|---|---|---|---|---|---|---|
| Cumulative RTB* increase | - | 0.1 | 0.2 | 0.3 | 0.3 | **0.9** |

*RTB - run-the-business ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 6.2 |
| High | 11.1 |

### 3.1.8 Options

| Option(s) | Pros | Cons |
|---|---|---|
| Not invest in this area | | • Doesn't enable easy and economic data-sharing with our customers.<br>• Creates staff overheads and technical debt as it addresses engagement problems with inefficient processes and workarounds.<br>• Requires higher level of investment in other areas to make up for engagement inefficiencies.<br>• Puts other prioritised costumer value areas in RIIO-2 plan at risk.<br>• Puts 2025 ambition of competition everywhere at risk.<br>• Doesn't enable transparency.<br>• Doesn't meet new customer data needs in a timely way.<br>• Maintains low costumer experience.<br>• Increases cyber security risk. |
| Carry on using our legacy tools | | • Doesn't support easy and economic data sharing with our customers.<br>• Creates staff overheads and technical debt as it addresses engagement problems with inefficient solutions and processes.<br>• Duplicates investment in other areas to make up for lack of engagement standard solutions.<br>• Puts other prioritised costumer value areas in RIIO-2 plan at risk.<br>• Puts 2025 ambition of full competition at risk.<br>• Doesn't enable transparency.<br>• Doesn't enable meeting new customer data needs in a timely way.<br>• Maintains low costumer experience.<br>• Increases cyber security risk. |

| Option(s) | Pros | Cons |
|---|---|---|
| Update tools and integrate with data platform, network control and enhanced balancing capabilities | • Enables 2025 ambition of full competition.<br>• Enables transparency.<br>• Enables easy and economic data sharing with our customers.<br>• Allows for scalability of investment.<br>• Enables objectives of other prioritised costumer value areas in RIIO-2 plan.<br>• Introduces engagement standards.<br>• Enables high and consistent costumer experience.<br>• Enables introduction of efficient processes.<br>• Enables quicker response to market needs. | |

## 3.2. 270 EU regulation

Current stage:

| Scoping | Start-up | Requirements and design | Development and testing | Implementation |
|---|---|---|---|---|

### 3.2.1 Overview

This investment enables the mandatory European Union 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.

### 3.2.2 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 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 3rd energy package (European network codes), which has a major impact on ESO operational processes. The changes have included:
  - Capacity allocation and congestion management guideline (CACM), and common grid model (CGM)

- General compliance
- 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.

### 3.2.3 Case for change

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.

### 3.2.4 Roadmap

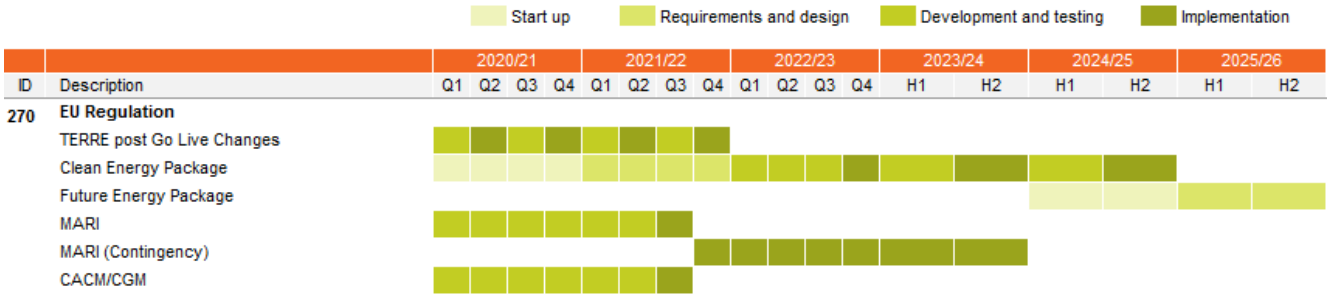


*Figure 31 – Delivery plan*

### 3.2.5 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 critical national infrastructure (CNI) systems.

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

- Completion of the 3rd 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 (4th) 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.

The nature and impact of regulatory change are very difficult to predict. Some unexpected changes could happen during the price control period, which may lead us to use Ofgem's proposed cost trigger mechanism.

### 3.2.6 Approach

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

### 3.2.7 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** |

Gartner benchmark range

| | |
|---|---|
| Low | 30.1 |
| High | 43.0 |

*RTB - run-the-business ongoing opex

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

### 3.2.8 Options

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

## 3.3. 280 GB regulation

Current stage:

| Scoping | Start-up | Requirements and design | Development and testing | Implementation |
|---|---|---|---|---|

### 3.3.1. 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.

### 3.3.2. 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 balancing and settlement code (BSC) modifications.
- Accelerated wider access.

### 3.3.3. Case for change

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

### 3.3.4. Roadmap

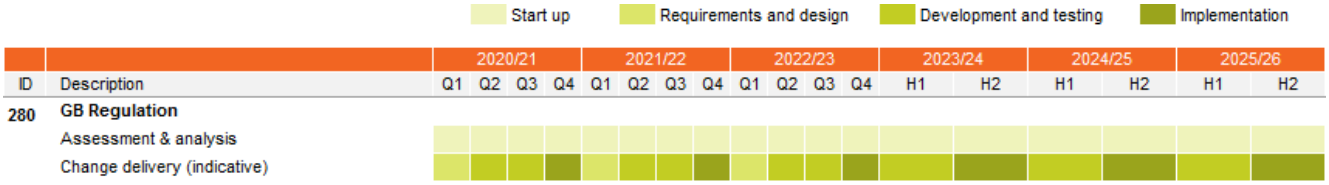


*Figure 32 – Delivery plan*

### 3.3.5. 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 estimate for 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.

Both the nature and impact of regulatory change are very difficult to predict. We could see some unexpected changes occurring during the price control period, which may lead us to use Ofgem's proposed cost trigger mechanism.

### 3.3.6. 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.

### 3.3.7. 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 | - | 0.1 | 0.2 | 0.2 | 0.3 | **0.8** |

*RTB - run-the-business ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 10.5 |
| High | 15.0 |

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

### 3.3.8. Options

| Option(s) | Pros | Cons |
|---|---|---|
| Not invest in this area | | • Doesn't comply with GB market & regulatory-driven change.<br>• Doesn't allow consumers and market participants to benefit from changes to the electricity markets. |
| Invest in enhancements | • Facilitates compliance with GB market & regulatory-driven change.<br>• Facilitates consumer and customer benefits from changes to the electricity markets. | |

## 3.4. 290 Charging and billing asset health

Current stage:

| Scoping | Start-up | Requirements and design | Development and testing | Implementation |
|---|---|---|---|---|

### 3.2.9 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 ESO. TNUOS charges go to the TOs, BSUOS charges to ESO, and connection charges are shared.

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

### 3.4.1. Current state

The current CAB system was implemented in 2014 and is being replaced by the revenue 21 project, which starts in RIIO-1 and is expected to complete by 2021/22.

### 3.4.2. Case for change

CAB 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 CAB, which the new ESO revenue systems will capture, supporting compliance requirements (e.g. Sarbanes Oxley) as well as introducing business efficiencies.

Two Ofgem significant code reviews are currently in progress. These are expected 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 & Forward Looking Charges Review due in 2023.

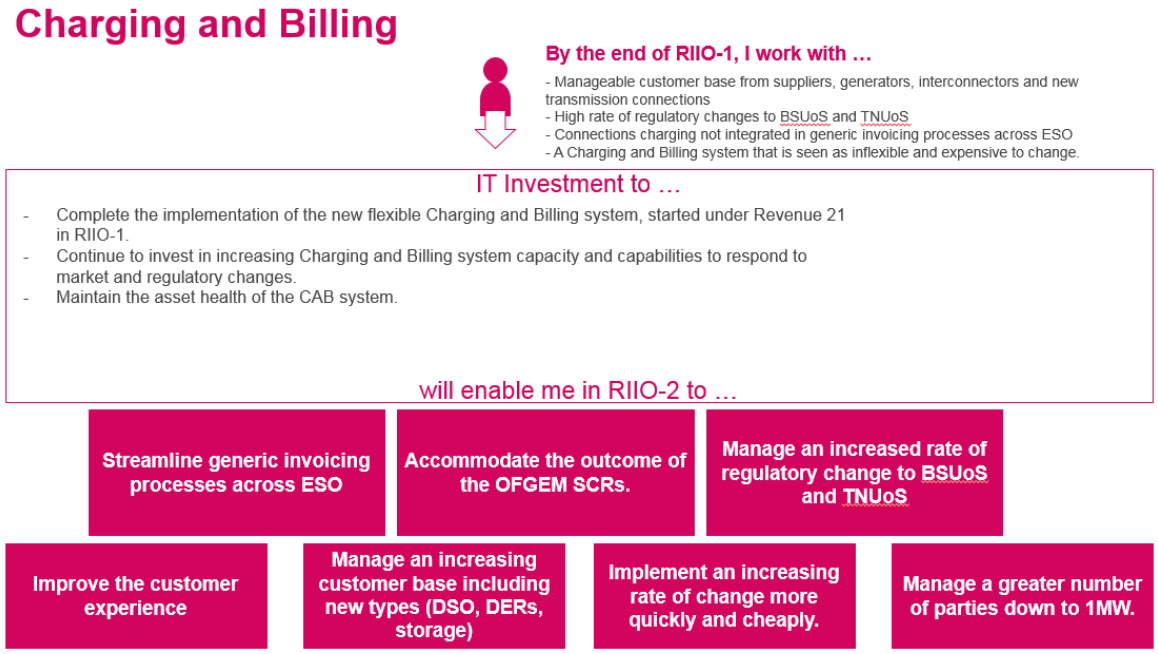


*Figure 33 - Use case, investment and outcome expectation*

### 3.4.3. Roadmap

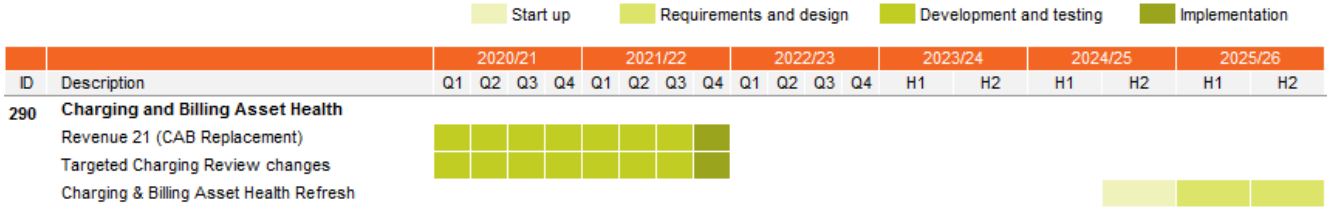


*Figure 34 – Delivery plan*

### 3.4.4. Future state

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

The new CAB 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.

The new system 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 new CAB system will require an asset health refresh early in the subsequent RIIO period and have included funding for this to begin in the final year of RIIO-2.

### 3.4.5. Approach

This investment allows for the completion of the new charging and billing system.

The cost table below assumes that this CAB replacement will be met by an off-the-shelf cloud solution. If customisation is required, a proportion of the expenditure will switch from opex to capex.

### 3.4.6. 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 | - | 0.2 | 0.3 | 0.5 | 0.6 | **1.6** |

*RTB - run-the-business ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 8.0 |
| High | 16.0 |

### 3.4.7. Options

| Option(s) | Pros | Cons |
|---|---|---|
| Not invest in this area | | • Puts our ability to manage the charging and billing process at risk.<br>• Leaves tools unsupported and at increasing risk of failure.<br>• Planned improvements in agility and flexibility would not be achieved.<br>• Puts ability to comply with OFGEM SCRs at risk.<br>• Puts ambition to transform the customer experience at risk.<br>• Increases cost and time to implement future charging and CUSC changes.<br>• Prolongs manual processes and increases inefficiencies.<br>• Increases cyber security risk. |
| Carry on investing in our legacy tools | • Mitigates risk to charging and billing process.<br>• Brings tools into support and reduces risk of failure.<br>• Mitigates cyber security risk. | • Puts ability to comply with OFGEM SCRs at risk.<br>• Puts ambition to transform the customer experience at risk.<br>• Planned improvements in agility and flexibility would not be achieved.<br>• Increases cost and time to implement future charging and CUSC changes.<br>• Prolongs manual processes and increases inefficiencies. |
| Update our tools | • Facilitates compliance with OFGEM SCRs.<br>• Facilitates ambition to transform the customer experience.<br>• Implements improvements in agility and flexibility.<br>• Reduces cost and time to implement future charging and CUSC changes.<br>• Removes manual processes and reduces inefficiencies.<br>• Mitigates risk to charging and billing process.<br>• Mitigates cyber security risk.<br>• Brings tools into support and reduces risk of failure. | |

## 3.5. 300 Charging regime and CUSC changes

Current stage:

| Scoping | Start-up | Requirements and design | Development and testing | Implementation |
|---|---|---|---|---|

### 3.5.1. Overview

This investment enables mandatory market-driven change to the connection and use of system code (CUSC) and/or the charging regime.

### 3.5.2. Current state

The connection and use of system code (CUSC) is the contractual framework for connection to, and use of, the national electricity transmission system (NETS). ESO is the code administrator and maintains the code and manage changes.

The CUSC sets out the methodology for calculation charges. 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 & 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 under way to replace this system by 2021/22, as described under '290 Charging and billing asset health' above.

### 3.5.3. Case for change

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

### 3.5.4. Roadmap

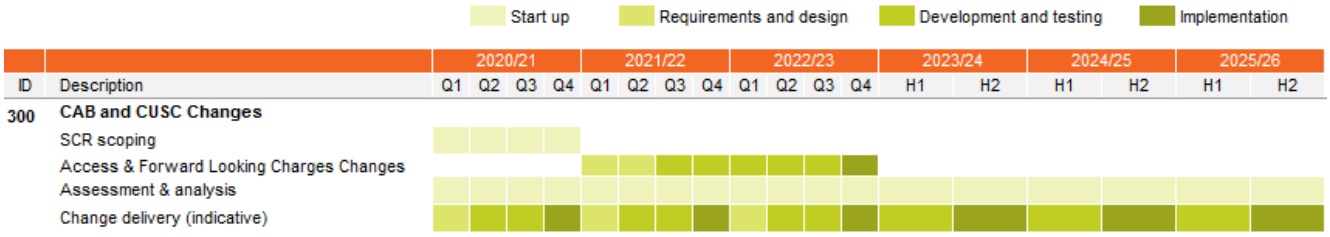


*Figure 35 – Delivery plan*

### 3.5.5. Future state

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

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.

### 3.5.6. Approach

We will build on the new capabilities established by the investment in '290 Charging and billing asset health'. There may be some scope to use the capabilities added by the data and analytics platforms and the digital engagement platform to implement CUSC changes efficiently i.e. using the integration, ETL, and analytical capabilities.

The cost table below assumes that this CAB replacement will be an off-the-shelf cloud solution. If customisation is required, a proportion of the expenditure will switch from opex to capex.

### 3.5.7. Costs

| Investment (£m) | 2021/22 | 2022/23 | 2023/24 | 2024/25 | 2025/26 | Total |
|---|---|---|---|---|---|---|
| Capex | - | - | - | - | - | - |
| Opex | 1.3 | 0.8 | 0.8 | 0.8 | 0.8 | **4.5** |
| **Total** | **1.3** | **0.8** | **0.8** | **0.8** | **0.8** | **4.5** |

| | | | | | | |
|---|---|---|---|---|---|---|
| Cumulative RTB* increase | - | 0.0 | 0.1 | 0.1 | 0.1 | **0.2** |

*RTB - run-the-business ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 3.1 |
| High | 3.6 |

Estimates exceed Gartner benchmark due to high level of change expected to arise from OFGEM SCRs. Annual expenditure falls in line with benchmark from FY23 onwards, once a new flexible system is implemented.

### 3.5.8. Options

| Option(s) | Pros | Cons |
|---|---|---|
| Not invest in this area | | • Doesn't comply with charging regime and CUSC changes.<br>• Doesn't 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.<br>• Facilitates consumer and customer benefits arising from changes to the charging regime and CUSC. | |

## 3.6. 330 Digitalised code management

Current stage:

| Scoping | Start-up | Requirements and design | Development and testing | Implementation |
|---|---|---|---|---|

### 3.6.1. Overview

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

### 3.6.2. 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.

### 3.6.3. Case for change

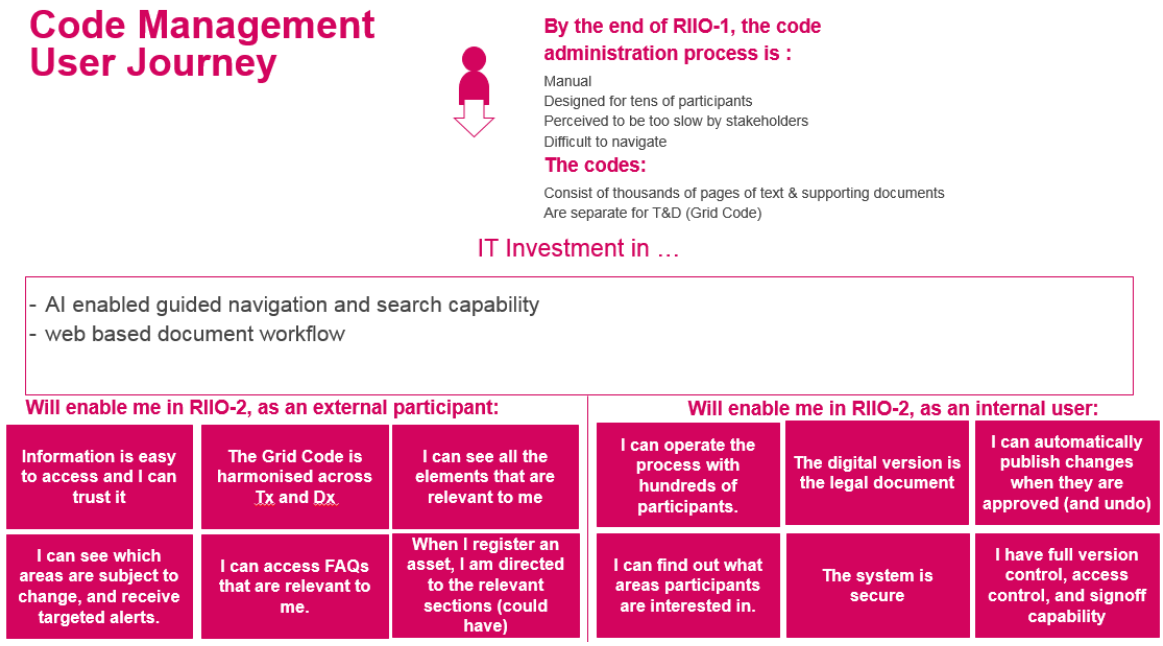


*Figure 36 - Use case, investment and outcome expectation*

### 3.6.4. Roadmap

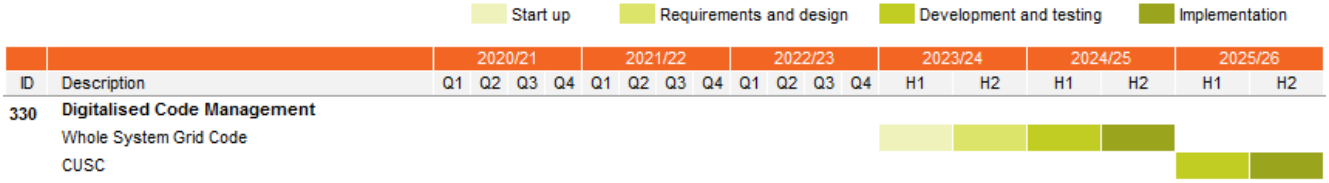


*Figure 37 – Delivery plan*

### 3.6.5. Future state

This investment will digitalise and transform the external user experience through AI -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).

### 3.6.6. 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 B2B integration.

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

### 3.6.7. Costs

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

*RTB - run-the-business ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 1.4 |
| High | 2.9 |

### 3.6.8. Options

| Option(s) | Pros | Cons |
|---|---|---|
| Not invest in this area | | • Doesn't enable the ambition to create a fully digitalised whole-system Grid Code.<br>• Doesn't enable the digitalisation of the energy system.<br>• Doesn't provide a more user-friendly, tailored experience for customers.<br>• Doesn't increase the pace of decision making.<br>• Process would remain manual.<br>• New participants would continue to find it difficult to understand the Grid Code, potentially creating a barrier to entry.<br>• 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.<br>• Provides a more user -friendly and tailored experience for customers.<br>• Enables quicker decision-making.<br>• Enables automation of processes<br>• New participants would find it easier to understand the Grid Code, and a barrier to entry would be removed.<br>• No need for additional resource to manage the process. | • Inconsistent user experience.<br>• Lack of scalability.<br>• Increased implementation cost due to lack of re-use of enabling technologies. |

| Option(s) | Pros | Cons |
|---|---|---|
| Invest in new tools and integrate with digital engagement platform | • Enables the ambition to create a fully digitalised whole-system Grid Code.<br>• Supports the digitalisation of the energy system, as recommended by the EDTF.<br>• Provides a more user friendly and tailored experience for customers.<br>• Enables quicker decision-making.<br>• Enables automation of processes.<br>• New participants find it easier to understand the Grid Code, and a barrier to entry would be removed.<br>• No need for additional resource to manage the process.<br>• Enables high and consistent customer experience.<br>• Allows for scalability of investment.<br>• Reduced cost from re-use of enabling technologies. | |

## 3.7. 400 Single markets platform

Current stage:

| Scoping | Start-up | Requirements and design | Development and testing | Implementation |
|---|---|---|---|---|

### 3.7.1. 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.

### 3.7.2. 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 (e.g. SRD, FCDM). 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.

### 3.7.3. 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 t operational needs. We need to have realistic testing capabilities where market participants can connect under development conditions to validate individual and industry benefits.

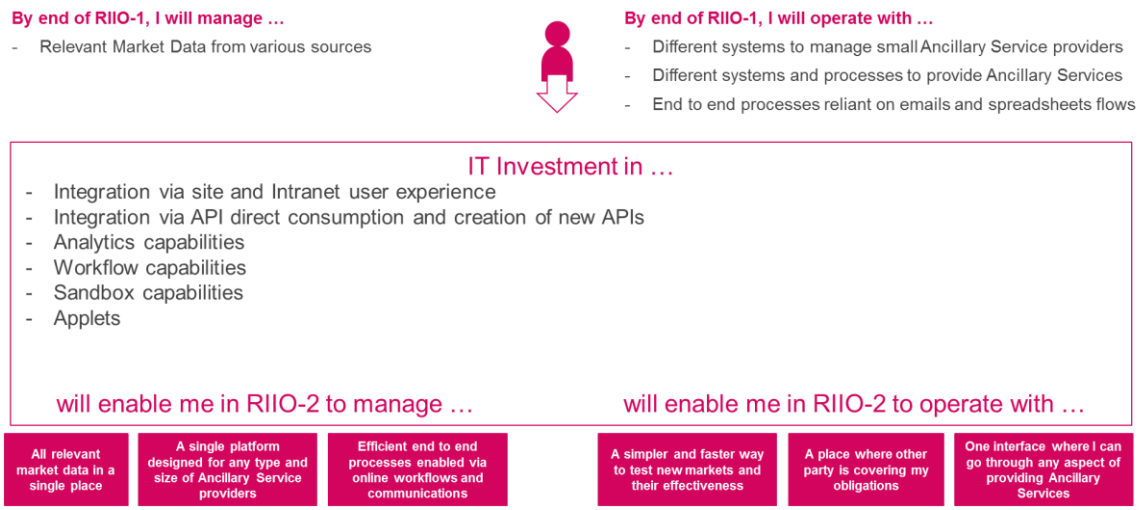


*Figure 38 - Use case, investment and outcome expectation*

### 3.7.4. 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 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.

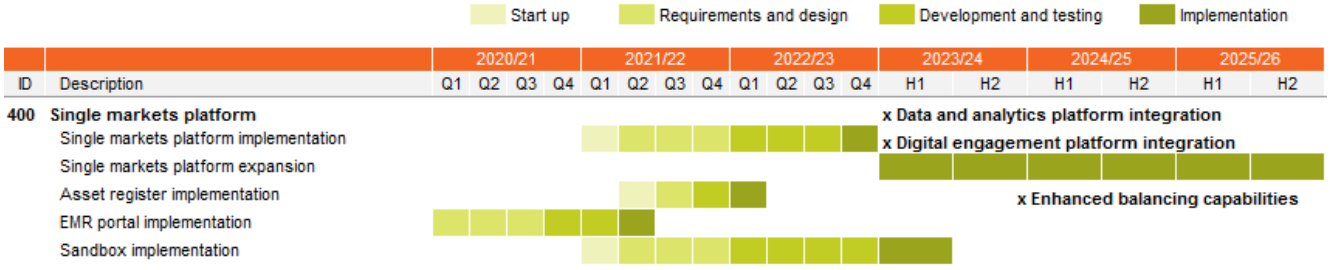


*Figure 39 – Delivery plan*

### 3.7.5. 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.

### 3.7.6. Approach

We will implement the single markets platform progressively using solution components and platforms provided by RIIO-1 and other RIIO-2 investments.

The single markets platform will deliver ESO services to participants from a single location while greatly increasing the level of automation to meet the much higher demand for 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. We will draw on external partners for these implementations.

AI will increase the level of automation and self-service.

Selected markets provided by third parties will be integrated into the single markets platform to give a consistent user experience and B2B access.

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

The single markets platform will be developed progressively to meet the needs of the RIIO-2 programme. Implementation 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 out sourced to our integration partners.

### 3.7.7. 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 | - | 0.6 | 1.1 | 1.5 | 1.8 | **5.0** |

Gartner benchmark range

| | |
|---|---|
| Low | 14.0 |
| High | 20.0 |

*RTB - run-the-business ongoing opex

### 3.7.8. Options

| Option(s) | Pros | Cons |
|---|---|---|
| Not invest in this area | | • No new markets or products will be created.<br>• Doesn't enable easy and economic data sharing with our customers.<br>• Creates staff overhead and technical debt as it addresses market procurement problems with inefficient processes and workarounds.<br>• Requires higher level of investment in other areas to make up for market procurement inefficiencies.<br>• Puts 2025 ambition to be able to operate a carbon free electricity system at risk.<br>• Puts 2025 ambition of competition everywhere at risk.<br>• Doesn't enable transparency of our actions.<br>• Doesn't react to or meet new customer data needs in a timely way.<br>• Increases operational risk.<br>• Maintains low costumer experience.<br>• Increases cyber security risk. |
| Carry on using our legacy tools | | • Doesn't support easy and economic data-sharing with our customers.<br>• Creates staff overheads and technical debt as it addresses engagement problems with inefficient solutions and processes.<br>• Duplicates investment in other areas to make up for lack of market procurement standard solutions.<br>• Puts at risk 2025 ambition to be able to operate a carbon free electricity system.<br>• Puts 2025 ambition of full competition at risk.<br>• Doesn't enable transparency.<br>• Doesn't react to or meet new customer data needs in a timely way.<br>• Maintains low costumer experience.<br>• Increases cyber security risk. |
| Update tools and integrate with digital engagement platform, data platform, network control and enhanced balancing capabilities | • Enables 2025 ambition of full competition.<br>• Enables 2025 ambition to be able to operate a carbon free electricity system.<br>• Enables transparency.<br>• Enables easy and economic data-sharing with our customers. | |

| Option(s) | Pros | Cons |
|---|---|---|
| | • Allows for scalability of investment.<br>• Introduces market procurement standards.<br>• Enables high and consistent costumer experience.<br>• Enables introduction of efficient processes.<br>• Enables quicker response to market needs. | |

## 3.8. 410 Ancillary service settlements refresh

Current stage:

| Scoping | Start-up | Requirements and design | Development and testing | Implementation |
|---|---|---|---|---|

### 3.8.1. 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.

### 3.8.2. 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.

### 3.8.3. Case for change

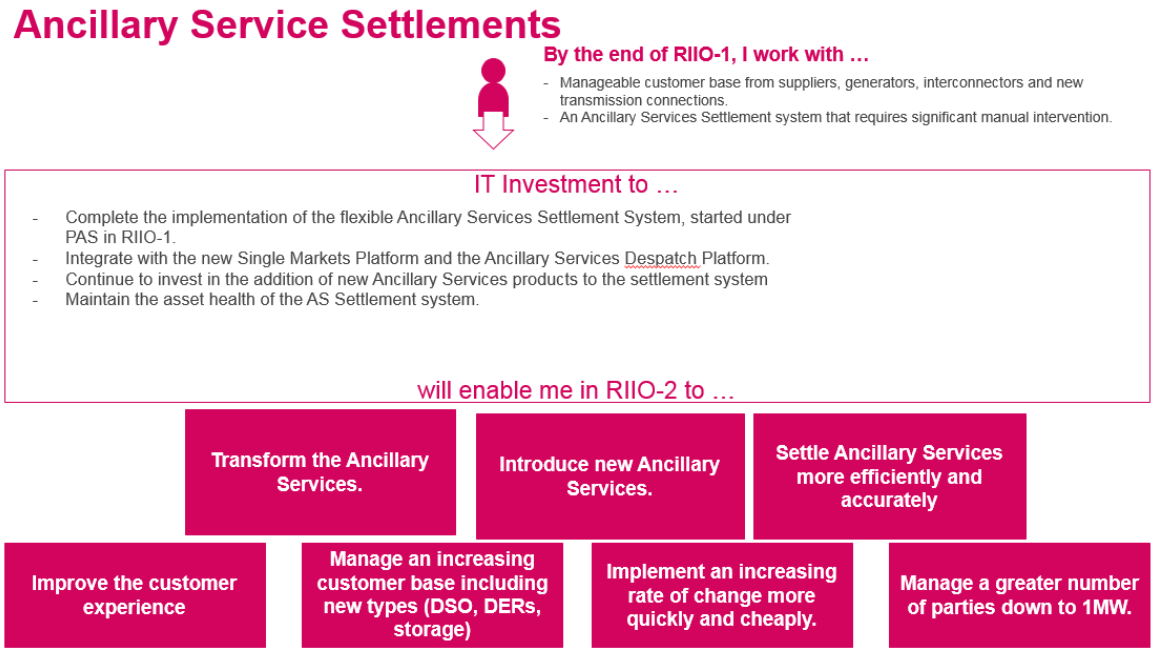


*Figure 40 - Use case, investment and outcome expectation*

### 3.8.4. Roadmap

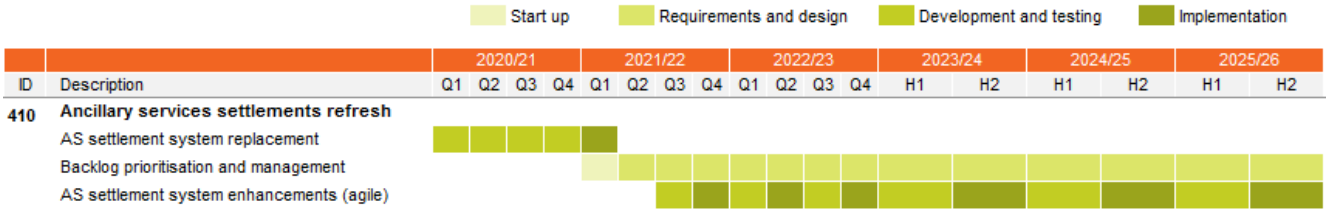


*Figure 41 – Delivery plan*

### 3.8.5. 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 increase 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.

### 3.8.6. 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. '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.

### 3.8.7. 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 ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 1.6 |
| High | 4.1 |

Estimate is higher than Gartner benchmark, as we plan to implement a new system in FY22, then continually enhance it to add new services throughout the RIIO-2 period.

### 3.8.8. Options

| Option(s) | Pros | Cons |
|---|---|---|
| Not invest in this area | | • Puts our ability to manage the settlements process at risk.<br>• Leaves tools unsupported and at increasing risk of failure.<br>• 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.<br>• Puts ambition to transform the customer experience at risk.<br>• Prolongs manual processes and increases inefficiencies.<br>• Increases cyber security risk. |
| Carry on investing in our legacy tools | • Mitigates risk to settlements process.<br>• Brings tools into support and reduces risk of failure.<br>• 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.<br>• Puts ambition to transform the customer experience at risk.<br>• Prolongs manual processes and increases inefficiencies. |
| Update our tools | • Facilitates ambition to transform the customer experience.<br>• Improves agility and flexibility.<br>• Reduces cost and time to implement future changes.<br>• Removes manual processes and reduces inefficiencies.<br>• Mitigates risk to settlements process.<br>• Brings tools into support and reduces risk of failure.<br>• Mitigates cyber security risk. | |

## 3.9. 420 Auction capability

Current stage:

| Scoping | Start-up | Requirements and design | Development and testing | Implementation |
|---|---|---|---|---|

### 3.9.1. 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, etc.

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

### 3.9.2. Current state

Medium term procurement of ancillary services is currently carried out via a tender process, on a monthly to tri annual basis. This is mainly underpinned by user-written spreadsheets. An 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.

### 3.9.3. Case for change

Current quarterly to annual tender 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 trend 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.

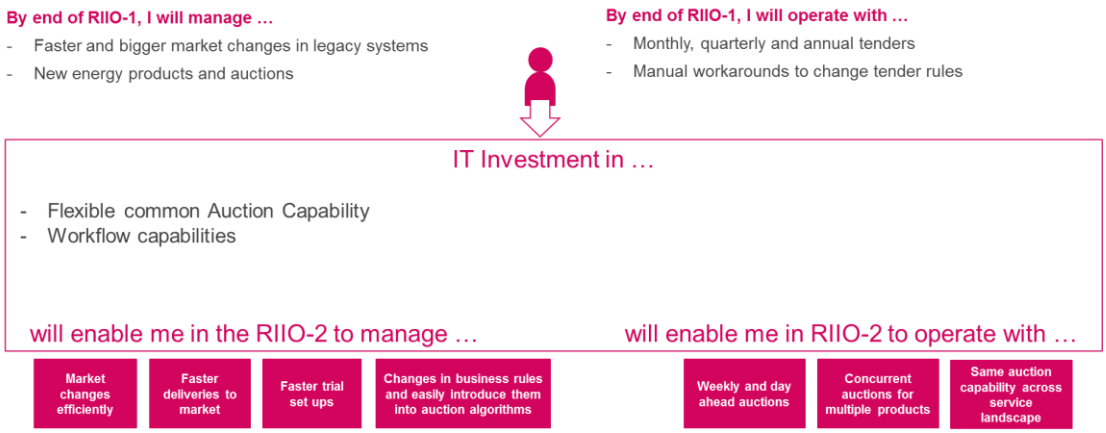


*Figure 42 - Use case, investment and outcome expectation*

### 3.9.4. 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.

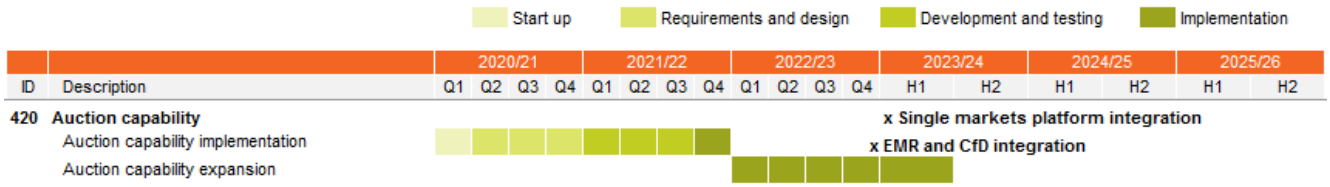


*Figure 43 – Delivery plan*

### 3.9.5. 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 '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 the '180 Enhanced balancing capabilities' and the '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 3rd party as it is not deemed CNI.

### 3.9.6. 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 ESO. 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.

### 3.9.7. Costs

| Investment (£m) | 2021/22 | 2022/23 | 2023/24 | 2024/25 | 2025/26 | Total |
|---|---|---|---|---|---|---|
| Capex | - | - | - | - | - | - |
| Opex | 4.0 | 2.0 | 2.0 | - | - | **8.0** |
| **Total** | **4.0** | **2.0** | **2.0** | - | - | **8.0** |

| | | | | | | |
|---|---|---|---|---|---|---|
| Cumulative RTB* increase | 0.1 | 0.5 | 0.8 | 1.0 | 1.0 | **3.4** |

Gartner benchmark range

| | |
|---|---|
| Low | 4.2 |
| High | 8.3 |

*RTB - run-the-business ongoing opex

### 3.9.8. Options

| Option(s) | Pros | Cons |
|---|---|---|
| Not invest in this area | | • No new auctions or tenders will be created.<br>• Increases operational risk.<br>• Puts at risk 2025 ambition to be able to operate a carbon free electricity system.<br>• Puts 2025 ambition of competition everywhere at risk.<br>• Puts single markets platform costumer value at risk.<br>• Maintains low costumer experience.<br>• Increases cyber security risk.<br>• Leaves tools unsupported and underperforming.<br>• Doesn't enable transparency. |
| Individual auction data energy package | • Enables transparency. | • Doesn't provide single-user experience.<br>• Duplicates investment in other areas to make up for lack of auction standard solutions.<br>• Prevents efficiencies through economies of scale.<br>• Puts single markets platform costumer value at risk. |
| All auctions in a single capability | • Enables single markets platform costumer value.<br>• Supports 2025 ambition of full competition.<br>• Supports 2025 ambition to be able to operate a carbon free electricity system.<br>• Enables transparency.<br>• Allows for economies of scale.<br>• Introduces market procurement standards.<br>• Enables high and consistent costumer experience.<br>• 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 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 - but we are only at the beginning of this journey.

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. We are also investigating new algorithms to allow faster stability assessment for control room purposes. We also need better tools to identify and plan for future stability issues.

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

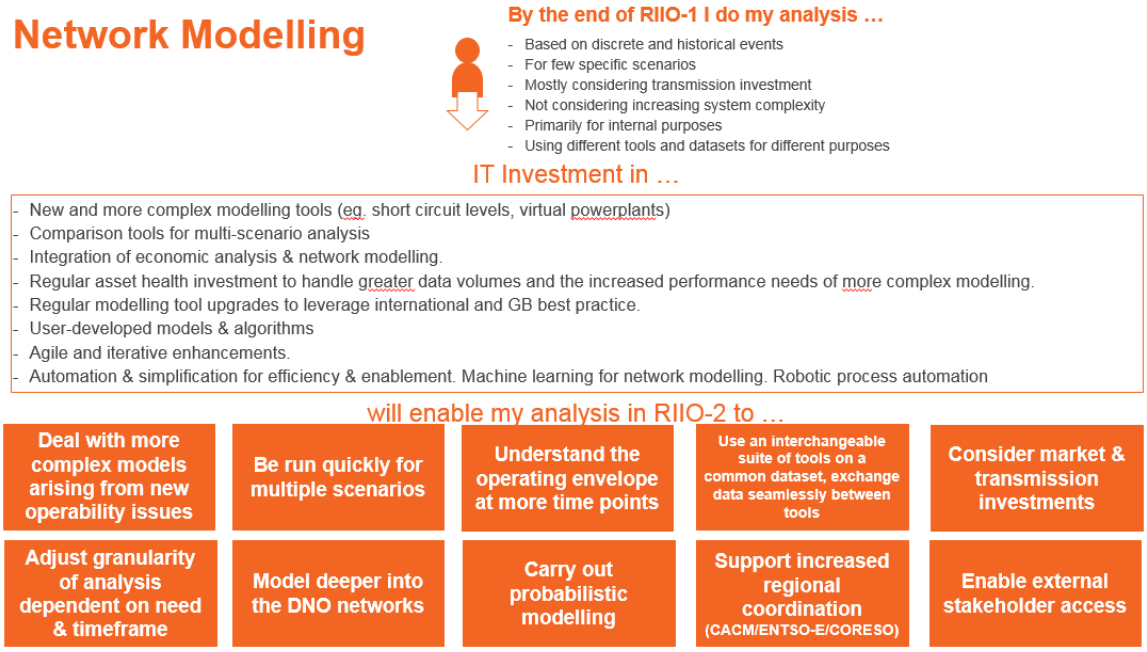


*Figure 44 - Use case, investment and outcome expectation*

We will integrate our NOA modelling and '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

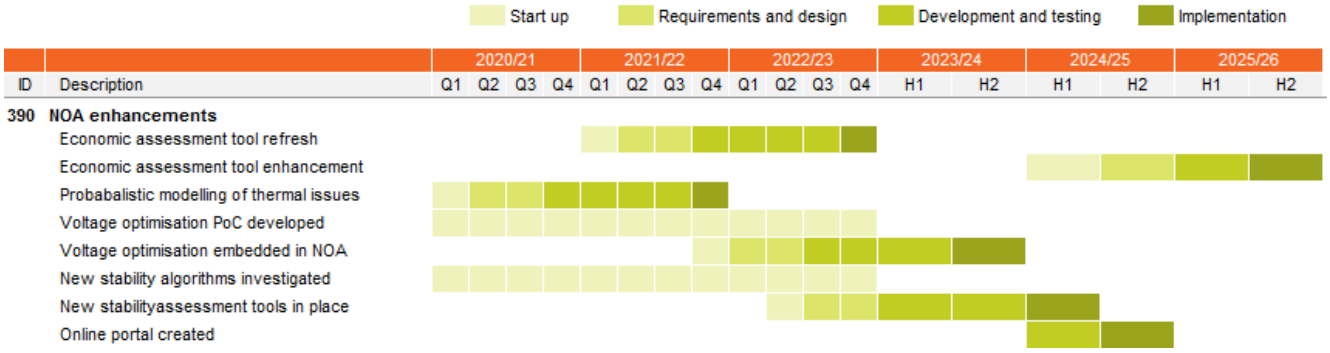


*Figure 45 – Delivery plan*

### 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 '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 '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.

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 (BoB) 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 requirements e.g. Digsilent PowerFactory and Pöyry BID3.

Where possible we will go to the market for new network modelling packages.

We will build our own network models using '220 Data and analytics platform'. NB: initial examples of this type of model are already in use or under construction.

We will build up our capability (team) in these skillsets.

The NOA platforms will be primarily cloud-based, inherited from the underlying platforms.

### 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 | - | 0.2 | 0.3 | 0.5 | 0.6 | **1.6** |

*RTB - run-the-business ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 8.0 |
| High | 16.0 |

We plan to invest strongly in this area, due to the level of benefits anticipated. So expenditure is at the high end of the benchmark.

### 4.1.8. Options

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

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 extension of regional development programmes (RDPs).

### 5.1.2. Current state

At present, 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-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 need.

### 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

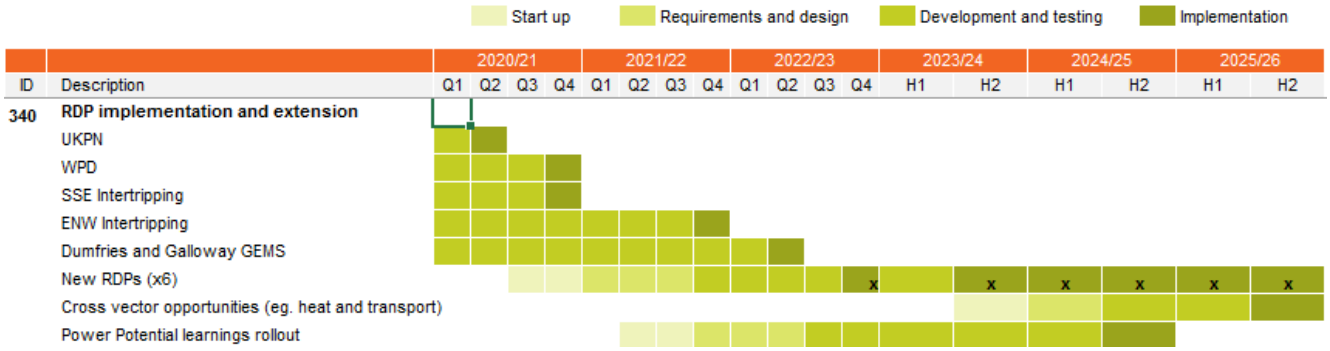


*Figure 46 – Delivery plan*

### 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.

This will also will 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 regional development programmes (RDPs) to other areas, or the introduction of new RDPs as required to solve network issues . This investment will fund three RDPs per annum. Our current RDP delivery costs are circa £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 areasof learnings from the power potential innovation project.

We will also consider opportunities and needs arising from the electrification of heat and transport and have included investment towards the end of the RIIO-2 period.

### 5.1.6. Approach

We will complement and extend the approach for '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 ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 27.3 |
| High | 27.3 |

Level of investment will depend on the nature of the evolving ESO/DSO relationship. Our working assumption is that the relationship will align least regrets with the collaborative approach described by the future worlds 'world B'. We have assumed that we will deliver six RDPs in the RIIO-2 period. Cost could vary if these assumptions are incorrect.

### 5.1.8. Options

.

| Option(s) | Pros | Cons |
|---|---|---|
| Not invest in this area | | • Prevent the benefits of the RDP approach.<br>• Doesn't support operational optimisation.<br>• Doesn't support resolution of network issues across the T-D interface.<br>• Delays the transition to whole-system operation.<br>• Delays the connection of new DER.<br>• Puts at risk 2025 ambition to be able to operate a carbon free electricity system.<br>• Increased operational risk from limited visibility of embedded generation.<br>• Increased risk of service conflicts between ESO and DSOs.<br>• Unable to benefit from learnings of the Power Potential project.<br>• Unable to address emerging cross-vector issues. |
| New enhanced capability | • Realises the benefits of the RDP approach.<br>• Enables operational optimisation, in line with the key findings of the EDTF.<br>• Supports resolution of network issues across the T-D interface.<br>• Enables the transition to whole-system operation.<br>• Enables to the connection of new DER.<br>• Facilitates the 2025 ambition to be able to operate a carbon free electricity system.<br>• Reduces operational risk from limited visibility of embedded generation.<br>• Reduces risk of service conflicts between ESO and DSOs.<br>• Enables the benefits of the learnings from the Power Potential project to be realised.<br>• 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

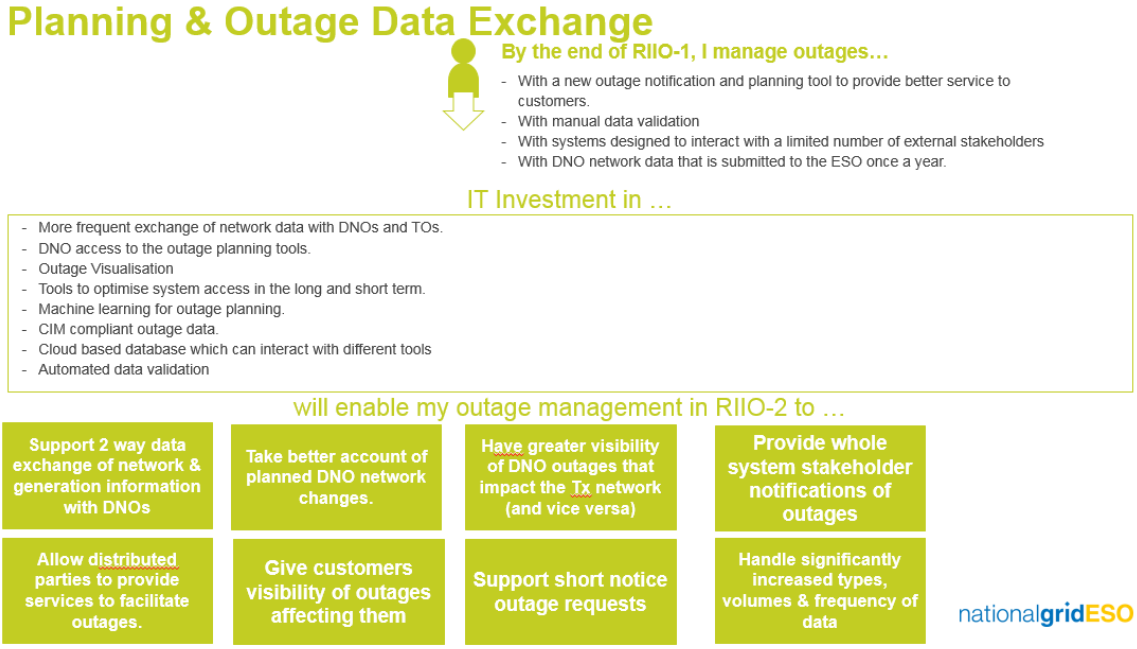


*Figure 47 - Use case, investment and outcome expectation*

## 5.2.4. Roadmap

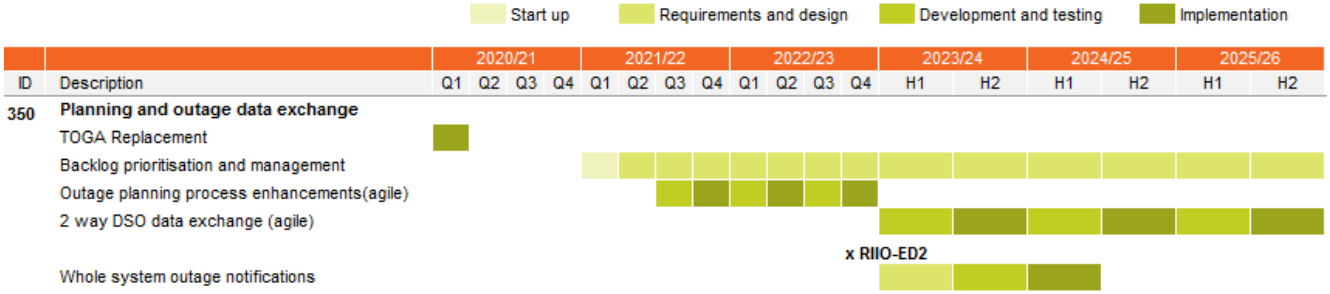


*Figure 48 – Delivery plan*

## 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-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, e.g. 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 ‘250 Digital engagement platform’ to provide a seamless experience to customers and stakeholders.

The external data exchange (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 ‘220 Data and analytics platform’. This will provide a seamless exchange of data between tools.

Investing in this area also aligns with the Energy Data Taskforce (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 bi-directional exchange of data in formats suitable for a range of data flows.

These services will be based on the enterprise data and analytical platforms and the digital experience platform. They will be developed to meet the needs of the RIIO-2 programme.

The enterprise data and analytical platforms and the digital experience platform provide for the widest range of application and data integration styles and these will be used to exchange situational data with participants, DSOs, the TSO and Ofgem.

These integration capabilities also enable the widest range of latencies (from real time down) and data volumes.

The artificial intelligence platform will be used to automate parts of the outage planning process.

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

The primarily cloud-based nature of the enterprise data and analytics platforms and the digital experience platform will align with the rest of the industry and enables the exchange of data via cloud storage.

### 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 | 0.1 | 0.1 | **0.2** |

*RTB - run-the-business ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 5.0 |
| High | 6.2 |

### 5.2.8. Options

| Option(s) | Pros | Cons |
|---|---|---|
| Not invest in this area | | • Does not facilitate a whole-system approach to outage planning.<br>• Does not facilitate the ambition to work more closely with DNOs and DERs to facilitate network access.<br>• Does not support infrastructure and asset visibility.<br>• Leaves operational tools unsupported.<br>• Increases cyber security risk.<br>• 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.<br>• Facilitates the ambition to work more closely with DNOs and DERs to facilitate network access.<br>• Maintains reliability of operational tools.<br>• Reduces cyber security risk.<br>• Facilitates exchange of greatly increased volumes of data. | • Does not support infrastructure and asset visibility.<br>• Tools would continue to operate with separate data sources, making dealing with an increasing workload more difficult.<br>• Inconsistent user experience.<br>• Lack of scalability.<br>• Increased implementation cost due to lack of re-use of enabling technologies. |

| Option(s) | Pros | Cons |
|---|---|---|
| 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.<br>• Facilitates a whole-system approach to outage planning.<br>• Facilitates the ambition to work more closely with DNOs and DERs to facilitate network access.<br>• Maintains reliability of operational tools.<br>• Reduces cyber security risk.<br>• Facilitates exchange of greatly increased volumes of data.<br>• Modelling tools would operate with the same data sources, mitigating an increasing workload.<br>• Enables high and consistent customer experience.<br>• Allows for scalability of investment.<br>• Reduced cost from re-use 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 10 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 10-year statement 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 reporting to Europe.
- BID3: used for NOA modelling (see 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 is RIIO-2.

### 5.3.3. Case for change

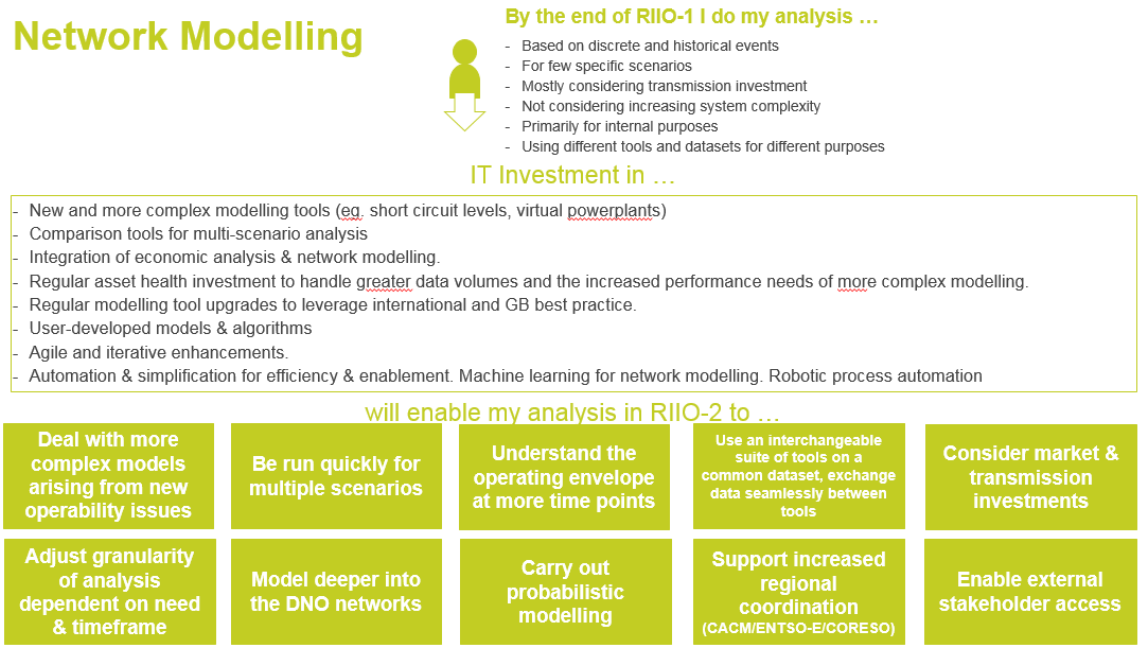


*Figure 49 - Use case, investment and outcome expectation*

We will integrate '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

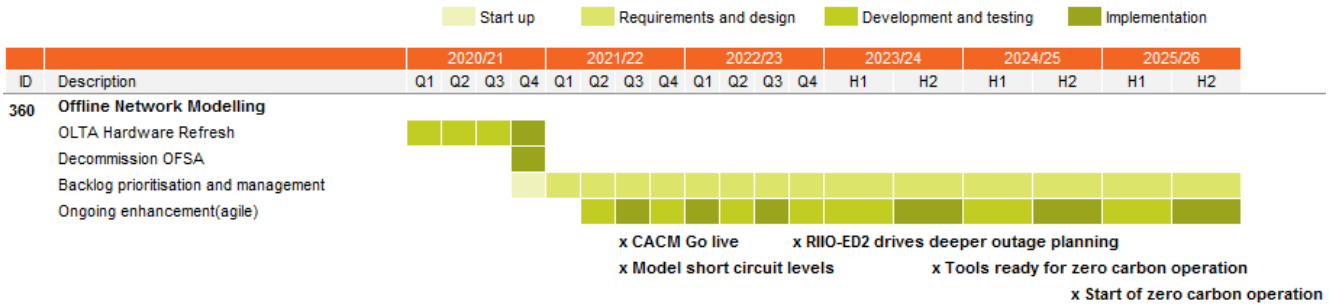


*Figure 50 – Delivery plan*

### 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 '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 '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 (e.g. short circuit levels, virtual powerplants, probabilistic modelling, multi scenario

analysis), including 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 (BoB) approach, combining commercial software and in-house developed analytic software using the same set of data science tools supplied by the enterprise data and analysis platforms.

### 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 | 0.1 | 0.1 | 0.2 | **0.3** |

*RTB - run-the-business ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 4.1 |
| High | 12.0 |

### 5.3.8. 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.<br>• Doesn't enable modelling of the increasing complexity of the power system.<br>• Modelling tools would continue to operate with separate data sources, making dealing with an increasing workload more difficult.<br>• Leaves operational tools unsupported.<br>• Increases cyber security risk. |
| Invest in stand-alone tools. | • Supports the 2025 ambition to be able to operate a carbon free electricity system.<br>• Enables modelling of the increasing complexity of the power system.<br>• Maintains reliability of operational tools.<br>• Reduces cyber security risk. | • Modelling tools would continue to operate with separate data sources, making dealing with an increasing workload more difficult.<br>• Does not enable holistic decision-making.<br>• Does not enable adjustment of the level of analysis. |
| Invest in tools and integrate with data & analytics platform | • Supports the 2025 ambition to be able to operate a carbon free electricity system.<br>• Enables modelling of the increasingly complex power system. | |

| Option(s) | Pros | Cons |
|---|---|---|
| | • Maintains reliability of operational tools.<br>• Reduces cyber security risk.<br>• Modelling tools would operate with the same data sources, thus mitigating an increasing workload.<br>• Enables holistic decision-making.<br>• Enables adjustment of the level of analysis. | |

## 5.4. 380 Connections platform

Current stage:

| Scoping | Start-up | Requirements and design | Development and testing | Implementation |
|---|---|---|---|---|

### 10.4.1. 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.

### 10.4.2. Current state

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

### 10.4.3. Case for change

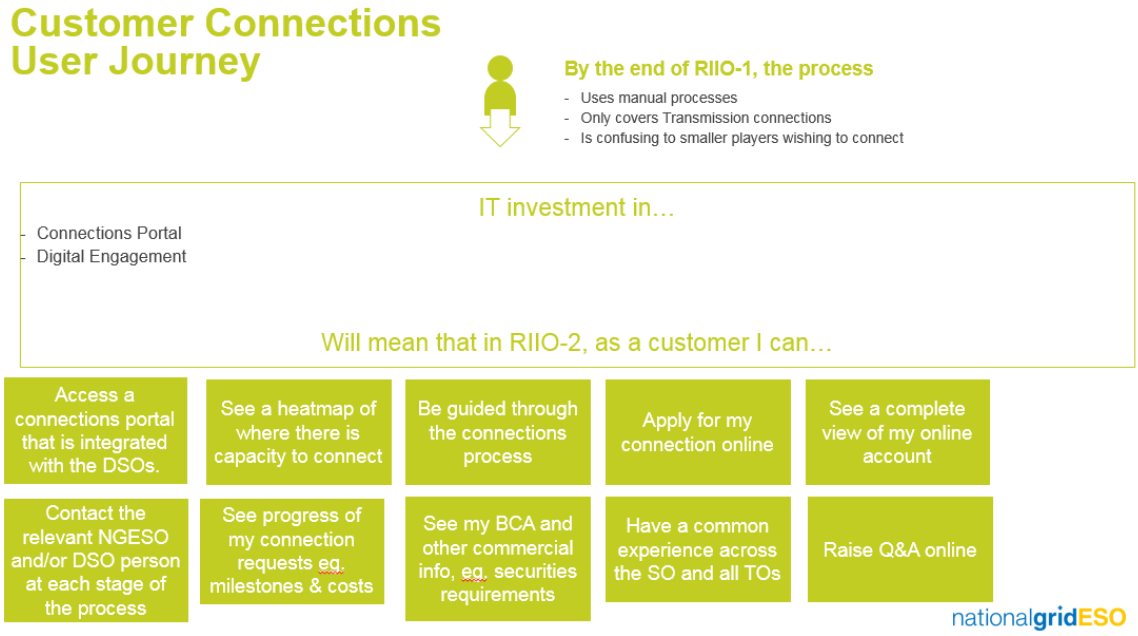


*Figure 51 - Use case, investment and outcome expectation*

## 10.4.4. Roadmap

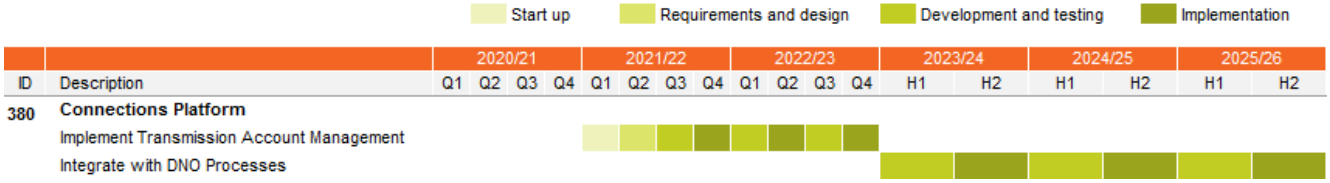


*Figure 52 – Delivery plan*

## 10.4.5. Future state

The hub will provide consistency in applying for connection across GB, 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, operational notifications, etc. It will be fully integrated with our digital engagement and customer relationship management tools to provide a seamless experience to customers and stakeholders.

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 Energy Data Taskforce (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.

## 10.4.6. Approach

We will build a new connections hub on the digital engagement platform, providing a single consistent user experience. The connections platform will sit in the SOA with a consistent set of APIs, allowing customers to integrate with their own internal processes.

We will automate connection processes to meet the increased volume and types of participants using the digital engagement platform as the main foundation for customer-centric processes. These will give much higher degrees of self-service and B2B API access. We will use external partners for these implementations.

The connections platform will be based on a master connections database built on the data platform.

Connections platforms processes will automate any connections governance or network design processes.

AI 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.

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

### 10.4.7. 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 | - | 0.1 | 0.1 | 0.1 | 0.1 | **0.4** |

*RTB - run-the-business ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 2.0 |
| High | 5.0 |

### 10.4.8. Options

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

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

### 5.4.1. Overview

Growth of low carbon and renewable generation, closure of conventional thermal power stations and changing interactions system are just a few of the areas impacting the operability of the power system through RIIO-2. Our proposals enable us to address these by operating a zero-carbon power system by 2025.

Increased capability is needed to maintain power system stability in a low carbon world. To achieve this, it will be necessary to implement a wide area monitoring and control system, based on the recently completed enhanced frequency control capability (EFCC) innovation project.

### 5.4.2. Current state

The EFCC Innovation 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 power plants.
- Battery storage.
- Wind power.
- Thermal generation.
- Demand side response (DSR).

### 5.4.3. Case for change

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

As more renewable sources are connected to the system and larger, inertia-rich, generators such as coal-fired power stations are replaced, maintaining the frequency response at 50 Hz – a license requirement – will become more challenging. New, significantly faster frequency, coordinated response solutions using renewables, demand-side resources, and other technologies need to be developed. The enhanced frequency control capability (EFCC) project was designed to find a solution to this challenge.

### 5.4.4. Roadmap

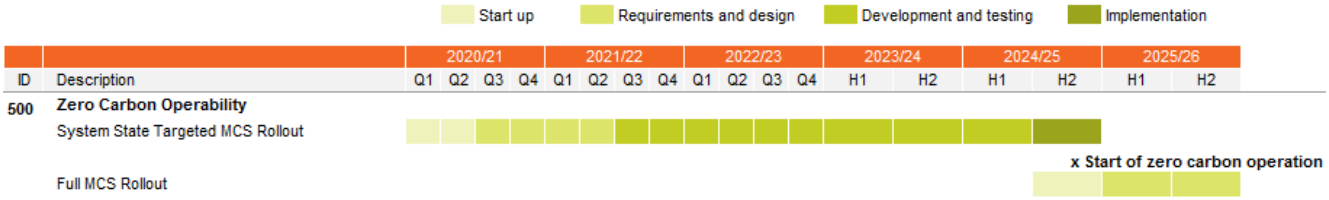


*Figure 53 – Delivery plan*

### 5.4.5. Future state

When a variance in frequency 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. The MCS provides the bridge between the technologies and the System Operator and automatically deploys the right 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 frequency response from a range of service providers. The MCS can detect an issue with system frequency 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 and at lower levels of system inertia 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 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.

Stability services will be integrated into control room tools, for example the new dispatch solution under ‘180 enhanced balancing capability’ in Theme 1. The MCS will rely on the inertia monitoring

capability being delivered by the investment in '130 emergent technology and system management', and the frequency monitoring capability being delivered by the investment in '170 frequency visibility'.

The MCS is reliant on a high-speed operational telecoms network provided by the Transmission Owner. We understand that the NGET RIIO-2 business plan includes this investment, and assume the upgraded network will provide sufficient speed and capacity to support this project.

### 5.4.6. Approach

We will implement the MCS as a bespoke application with an external partner. It will have high availability and resilience. It will be geographically diverse with no single points of failure.

The implementation project will use significant trialling/proof of concept stages to verify the solution before commiting to full implementation.

The MCS will be used on our CNI estate in our data centres and will use dedicated control network provided by the TO with guaranteed performance and service levels.

### 5.4.7. 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 | - | 0.5 | 1.1 | 2.0 | 2.5 | **6.0** |

*RTB - run-the-business ongoing opex

Gartner benchmark range

| | |
|---|---|
| Low | 24.9 |
| High | 24.9 |

The EFCC project developed a series of implementation estimates based on different Future Energy Scenarios (FES) and levels of distribution participation. 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 Dx connected providers is greater, costs could increase significantly.

### 5.4.8. 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.<br>• Increased operational risk from low levels of synchronous generation and inertia.<br>• Increased operational risk arising from power system stability issues.<br>• Unable to manage regional stability issues in a coordinated manner.<br>• Delays the transition to whole-system operation.<br>• Unable to benefit from learnings of the EFCC project. |
| New enhanced capability | • Facilitates the 2025 ambition to be able to operate a carbon free electricity system. | |

| Option(s) | Pros | Cons |
|---|---|---|
| | • Reduces operational risk from low levels of synchronous generation and inertia.<br>• Reduces operational risk from power system stability issues.<br>• Enables management of regional stability issues in a coordinated manner.<br>• Facilitates the transition to whole-system operation.<br>• Enables the benefits of the learnings of the EFCC project to be realised. | |

# 6. Shared investments: business services

## 6.1. Executive summary

National Grid delivers business services to ESO via a shared services model with support functions providing delivery of common services such as IT, property management, HR and finance to all the National Grid group businesses. They support the delivery of our core activities, helping us to find and retain our people, manage our IT systems, and provide financial stewardship. Our support functions also perform key business activities such as health and safety, legal compliance and estate management.

**In RIIO-2, as a group, we look to invest £115.5 million (£16.9 million allocation for ESO) to maintain and evolve the IT systems supporting these group functions. This has been independently benchmarked by Gartner to be within our peer group range.**

In RIIO-1 we focused on establishing core standard technology platforms that would allow the efficient delivery of business services across the UK functional entities. We have now established our core ERP services on SAP S/4HANA, our employee services on SAP SuccessFactors, and our service desks function on ServiceNow. We have also consolidated all risk functions on to a single governance, risk management, and compliance (GRC) platform.

This strategy has met the immediate needs of the functional entities and provides the required 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. 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. We can exploit and unlock new functionality to further increase our efficiency, whilst maintaining a secure and controlled eco-system.

Without maintenance of our systems, the investments made in RIIO-1 will become outdated and inefficient, exposing us to increased cyber risk and operational failure. Without the continued exploitation of new capabilities there will be a stagnation of our ability to deliver the 1.1 per cent efficiencies needed to meet our business plan year-on-year improvement in operating productivity, which represents almost three times the current UK trend for productivity improvement.

## 6.2. Introduction

National Grid operates a ‘shared service’ model for each of the supporting functions, allowing each function to provide services across a number of National Grid group businesses. This creates economies of scale in delivering these services. Internally, these support functions are organised into the following 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.

The back office 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 applications |
| • Other Core Functions |

## 6.3. Background information

### Over-arching back-office technology strategy

ERP is at the heart of our systems strategy. 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.

The diagram below shows the systems in scope that underpin the services offered by the supporting functions; it highlights the interconnected nature of National Grid controlled solutions versus SaaS:

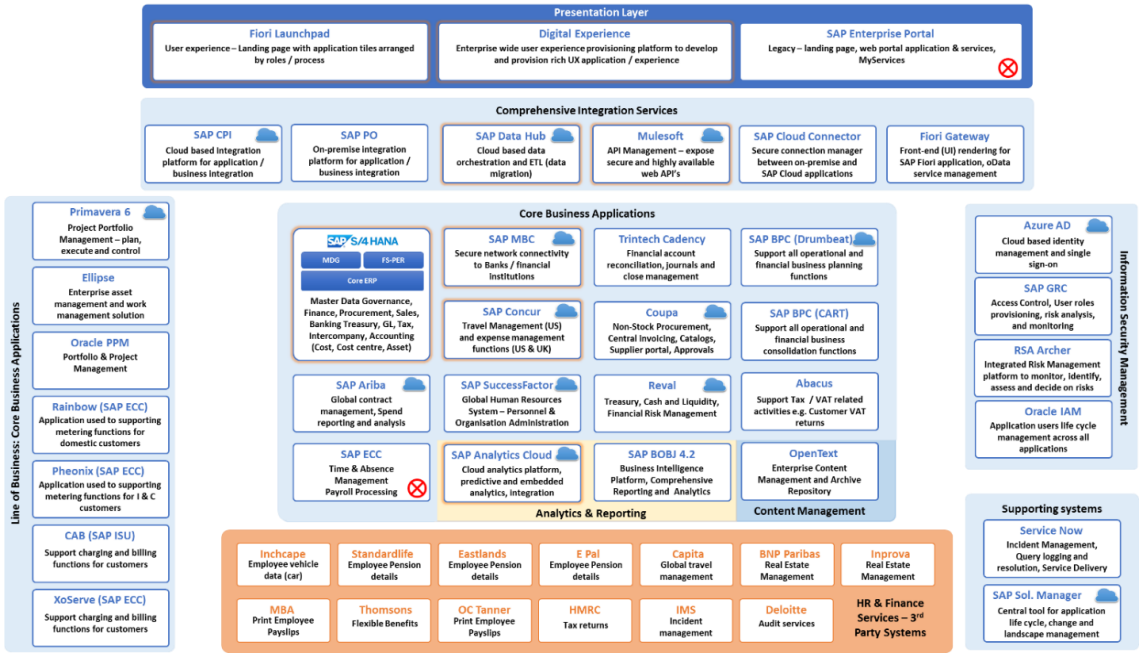


*Figure 54 – Systems underpinning group IT services offering for ESO*

National Grid's 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, National Grid 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, National Grid would migrate to an SAP SaaS offering midway through the RIIO-2 period, subject to commercial considerations.

In RIIO-2 these strategic platforms will continue to be at the heart of our back office systems. They deliver our core finance, procurement and HR services and are the single source of data for operational and business systems across the organisation to offer better controls and lower costs.

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

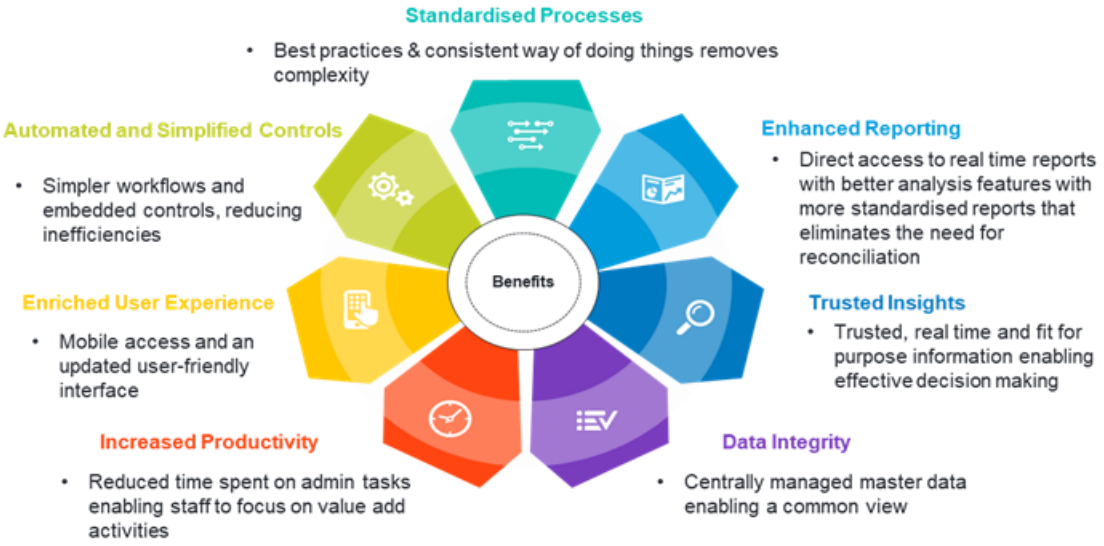


*Figure 55 – Benefits built on in RIIO-2*

In the years ahead through RIIO-2, these benefits will be extended as we invest in deepening the digital transformation for National Grid, 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 agenda for utilities they noted the two focus areas are data analytics (including advanced analytics) and 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 AI 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.

Through RIIO-1 we responded to Ofgem's challenge 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. However, as we continued through RIIO-1 we found this impacted the productivity and effectiveness of our employees. Coupled with the increasing threat of cyber-attack on our systems, it resulted in a review of the IT asset health policy. Taking on these learnings, we have updated our IT asset health policiesand had them reviewed by independent IT experts, Gartner, who confirmed 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 deliver further efficiencies whilst mitigating the risk of cyber attacks.

## 6.4. 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)

IT will face increasing pressure to integrate many SaaS solutions or, as the market matures through acquisition, consolidation and new capabilities, to switch from one provider to another. For some business critical or complex systems this will lead to significant migration costs.

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 - procurement, Reval - treasury). This subscription-based model buying software-as-a-Service (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 National Grid 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. However, as the SaaS market fully matures throughout the RIIO-2 period we will have to manage the risk of market consolidation, and acquisitions, which may lead to significant IT costs switching to SaaS solutions or between providers.

### Data 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.

In line with our approach to continuous innovation, we will continue to build on the core capabilities and invest £5 million as a group to achieve this through:

- Intelligent data tools to consolidate/virtualise data improving governance and integrity.
- Hybrid analytics blending on-premise and cloud data sets.
- Machine learning and smart insights to increase predictive capabilities.
- What-if scenario value analysis predicting future outcomes.
- Natural language generation data storytelling increasing cognitive computing.
- Online collaborative analysis and data virtualisation.

There will also be opportunities to rationalise other reporting and analytics tools/processes. We intend to decommission SAP BOBJ within the finance and business services area where functionality will be available via SAC. This will further reduce data and analytics costs.

### Robotic process automation (RPA) and artificial intelligence (AI)

RPA AI will be expanded across the services. The availability and lower cost of compute power and storage is enabling the processing of large (big) data-sets which drive investment in robotics, automation and AI. AI includes technologies such as machine and deep learning and natural-language processing. In RIIO-2 we plan to invest £5.5 million as a group, covering both short- and medium-term improvements and capability build.

In the short-term, adoption of robotics and basic automation, particularly of data entry or low cognitive activities, will need to grow simply for us to remain competitive. We are already seeing the successful adoption of RPA in business services and expect this to expand. The market for offshore processing will increasingly need to be economically viable as the robotics and basic automation is cheaper, quicker and more accurate than human processing. The short-term benefit of robotics could eventually become an inhibitor of business improvement where more transformational change is needed, resulting in wholesale application changes and consolidation.

In the medium-term AI and machine learning (ML) will become more capable, 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 that RPA is unable to do today without human support. ML is used to build capability as systems learn to deal with exceptions and automate more of the processes. Within core finance, ML will be expanded and build on capability delivered in the RIIO-1 period with S/4HANA. The cognitive and conversational capabilities that were too difficult to address, or commercially unviable, will no longer be out of reach. Initially use will be fairly routine, for example, of advanced conversational web-chat agents (chat-bots) processing employee HR queries. As AI becomes more pervasive this will bring a paradigm shift where our systems morph from being workflow-focused in assisting workers towards a model where workers are

assisting our systems and providing insight into business performance, moving towards a more connected ecosystem.

## 6.5. 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 to SAP S/4HANA. 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 56 – Digital core key elements*

**As we move into RIIO-2 we will need to invest £73.06 million as a group 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 system(s) to the supported software releases to maintain security and continue enabling seamless connectivity with SaaS solutions. Investment in the new capabilities (such as AI, RPA, ML and data & analytics) will be needed to enable the business to deliver ongoing efficiency saving (reference 1.1 per cent).

| | | Totex (£m) | | | | | |
|---|---|---|---|---|---|---|---|
| Business Area | Investment Name | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | Total |
| Finance | Banking System Upgrade | 0.5 | 0.1 | 0.1 | 0.1 | 0.25 | 1.05 |
| | Business Planning | 0 | 3 | 0 | 0 | 0 | 3 |
| | Continuous Process Improvement / Maintenance | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 7.5 |
| | Enhanced Tax Reporting and Analysis Tools | 0.015 | 0.05 | 0.015 | 0.05 | 0.01 | 0.14 |
| | ERP | 5.25 | 5.25 | 5.25 | 5.25 | 5.25 | 26.25 |
| | Making Tax Digital – HMRC Digitization Agenda | 0.04 | 0.01 | 0.03 | 0.01 | 0.03 | 0.12 |
| | OpenText | 1 | 0 | 0 | 0 | 3 | 4 |
| | Payroll | 0 | 0 | 0 | 3 | 0 | 3 |
| | Portal | 3 | 0.5 | 0.5 | 0.5 | 1 | 5.5 |
| | RPA, Machine Learning & AI | 2 | 0.5 | 0.5 | 0.5 | 2 | 5.5 |
| | SAP Analytics Cloud | 1 | 1 | 1 | 1 | 1 | 5 |
| | SAP BPC (Group Financial Controls) | 0 | 0 | 0 | 0 | 4 | 4 |
| | Statutory / Regulatory / Compliance Activities | 1.5 | 1 | 1.5 | 1 | 1.5 | 6.5 |
| | Treasury Management System Enhancements | 0.75 | 0 | 0.75 | 0 | 0 | 1.5 |
| Finance Total | | 16.555 | 12.91 | 11.145 | 12.91 | 19.54 | 73.06 |

*Figure 57 – Group investment in Finance systems*

## 6.6. 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..

**During the RIIO-2 period we plan to invest £10.9 million as a group in these areas, 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 AI and robotics to automate the contract to award processes, reducing human input and increasing efficiency.

Within source to contract 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.

| | | Totex (£m) | | | | | |
|---|---|---|---|---|---|---|---|
| Business Area | Investment Name | # | 22/23 | 23/24 | 24/25 | 25/26 | Total |
| Procurement | Expense Management | 0 | 0 | 0.5 | 0 | 0.5 | 1 |
| | Fieldglass Replacement | 0 | 0.25 | 0 | 0 | 0 | 0.25 |
| | Global Procurement Supplier Relationship Management | 0.2 | 0 | 0.2 | 0.8 | 0 | 1.2 |
| | Global Procurement System Replacement | 0.5 | 0 | 0.5 | 1 | 2 | 4 |
| | Purchase to Pay Upgrade & Enhancements | 2 | 0 | 0 | 0 | 2 | 4 |
| | Travel & Booking | 0 | 0 | 0.4 | 0 | 0 | 0.4 |
| Procurement Total | | 2.7 | 0.25 | 1.6 | 1.8 | 4.5 | 10.85 |

*Figure 58 – Group investment in procurement systems*

## 6.7. HR and workforce systems

**We plan to invest £10 million as a group 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, branded internally as MyHub.

The Y & Z generations 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, creating a business culture of mobile first. Our systems will need to support flexible working, a more open and social approach to collaboration, that is increasingly automated, intelligent and very data-centric.

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 t through incremental efficiencies and effectiveness.

Building on the investment made in the Success Factors platform during the RIIO-1 period, we will continue to increase the benefits from the new functionality the platform provides, particularly focusing on data leveraging. 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.

| | | Totex (£m) | | | | | |
|---|---|---|---|---|---|---|---|
| Business Area | Investment Name | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | Total |
| HR | Case Management | 0.35 | 0 | 0.05 | 0 | 0 | 0.4 |
| | Data Archiving | 0 | 0.55 | 0 | 0 | 0 | 0.55 |
| | Digitising Learning | 0.7 | 0 | 0.15 | 0 | 0 | 0.85 |
| | GHR Main Policy Compliance | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.5 |
| | MyHub (SAP SuccessFactors) Upgrade & Enhancements | 1.1 | 4.25 | 2.1 | 0.1 | 0.1 | 7.65 |
| **HR Total** | | **2.25** | **4.9** | **2.4** | **0.2** | **0.2** | **9.95** |

*Figure 59 – Group investment in HR systems*

## 6.8. Digital and web applications

**We intend to invest £8.3 million as a group 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.**

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.

| | | Totex (£m) | | | | | |
|---|---|---|---|---|---|---|---|
| Business Area | Investment Name | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | Total |
| Digital Web Apps | Digital Service Integration | 0 | 0.2 | 0 | 0 | 0.2 | 0.4 |
| | External Channels Improvement | 0.25 | 0 | 0.25 | 0 | 0.25 | 0.75 |
| | Intranet refresh | 0 | 0 | 0 | 0 | 3.5 | 3.5 |
| | Internal Channels Improvement | 0.25 | 0 | 0 | 0.25 | 0 | 0.5 |
| | NG.com External Website Refresh | 0 | 2.15 | 0 | 0 | 0 | 2.15 |
| | Stakeholder and Internal Apps | 0.75 | 0 | 0 | 0 | 0 | 0.75 |
| | WEB Minor Works | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.25 |
| **Digital Web Apps Total** | | **1.3** | **2.4** | **0.3** | **0.3** | **4** | **8.3** |

*Figure 60 – Digital web application investments*

## 6.9. 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
- IT for IT

**Investments of £13.4 million as a group are required during the RIIO-2 period to refresh, sustain and/or implement capability and functionality for these core functions.**

Safety is and always will be National Grid’s 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.

| | | Totex (£m) | | | | | |
|---|---|---|---|---|---|---|---|
| Business Area | Investment Name | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | Total |
| Other Core Apps | Agile Development Tooling | 0 | 0 | 0.4 | 0 | 0 | 0.4 |
| | Audit Analytics & Visualisation | 0.35 | 0 | 0.05 | 0 | 0.05 | 0.45 |
| | Boardvantage | 0.15 | 0 | 0 | 0 | 0 | 0.15 |
| | Corporate Regulated Minor Works | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.75 |
| | Customer / Stakeholder Analytics | 0.5 | 0 | 0 | 0 | 0.25 | 0.75 |
| | Investor Relations Web Technology Refresh | 0.5 | 0 | 0 | 0 | 0 | 0.5 |
| | IT Provisioning and Software Licence Asset Mgt | 0 | 0 | 0.5 | 0.2 | 0 | 0.7 |
| | IT Tools for Planning and Delivery | 0.6 | 0.05 | 0.1 | 0.05 | 0.1 | 0.9 |
| | Legal Analytics & Visualisation | 0.4 | 0 | 0.1 | 0 | 0 | 0.5 |
| | Legal Contract Automation | 0 | 0 | 0.31 | 0 | 0 | 0.31 |
| | Legal Matter Mgt Upgrade & Enhancements | 0.6 | 0 | 0.1 | 0 | 0 | 0.7 |
| | RSA Archer Upgrade & Refresh | 0.6 | 2.05 | 0.6 | 0.05 | 0.4 | 3.7 |
| | Service Management Tool | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 1.5 |
| | Upgrade of IMS System | 0 | 0.5 | 0.1 | 0 | 0 | 0.6 |
| | SHS Enhanced Capability | 0.45 | 0.35 | 0.23 | 0.22 | 0.2 | 1.45 |
| **Other Core Apps Total** | | **4.6** | **3.4** | **2.94** | **0.97** | **1.45** | **13.4** |

*Figure 61 – Other core application investments*

## 6.10. Options

### Finance

The following table describes the high-level options considered for this business theme.

| Option | * TCO over RIIO-2 | 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** |
| | £35m | • A reduced team could deliver this option<br>• Losing team members would reduce future capability | • Will erode productivity due to stagnating processes<br>• Inhibit ability to benefit from new capabilities in the future | • | • Could result in manual offline process work-arounds<br>• Limited ability to exploit efficiencies offered by new features and functions | |
| Maintain, Enhance & 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** |
| | £65m | • Solution Development Team in place<br>• Support model matured from RIIO-1 system deployment | • Maximise return on investment from RIIO-1<br>• Support business pursuit of further efficiencies | • | • 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** |
| | £150-£175m | • Would require significant FTE effort | • Wasted sunk cost in S4 Hana during RIIO-1 | | • Premature investment in replacing application estate | |
| | | | | | | |
| | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |

## Procurement

The following table describes the high-level options considered for this business theme.

| Option | * TCO over RIIO-2 | Capacity to Deliver | Business / Strategic Fit | Addressing the problem | Risk | Overall |
|---|---|---|---|---|---|---|
| Maintain Only | AMBER<br>IN s/s | GREEN<br>• A reduced team could deliver this option<br>• Losing team members would reduce capability to deliver in the future | RED<br>• Will erode productivity due to stagnating processes<br>• Inhibit ability to benefit from new capabilities in the future | | AMBER<br>• Could result in manual offline process work-arounds<br>• Limited ability to exploit new efficiencies offered by new features and functions | **Rejected** |
| Maintain, Enhance & Evolve | GREEN<br>In s/s | GREEN<br>• Solution Development Team in place<br>• Support model matured from RIIO-1 system deployment | GREEN<br>• Maximise return on investment from RIIO-1<br>• Support business pursuit of further efficiencies | | GREEN<br>• Internal capability/expertise is required to ensure that new functions and features are exploited in a cost-efficient way | Recommended |
| Replace | RED<br>£6m | RED<br>• Would require significant FTE effort | RED<br>• Wasted sunk cost in Coupa during RIIO-1 | | RED<br>• Premature investment in replacing application estate | **Rejected** |

## HR and Workforce Systems

The following table describes the high-level options considered for this business theme.

| Option | * TCO over RIIO-2 | Capacity to Deliver | Business / Strategic Fit | Addressing the problem | Risk | Overall |
|---|---|---|---|---|---|---|
| Do nothing during RIIO-2 (no further maintenance / enhancement) and defer till T3 | **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** |
| | | | • Won't meet technology evergreen policy to remain n-1<br>• Inhibit ability to use new capabilities in the future | • No impact on improving efficiency<br>• Or stakeholder experience | • Security vulnerabilities will not be addressed<br>• Legal/mandatory updates not possible<br>• Tax updates not possible<br>• Vendor support | |
| Outsource | **This option is to completely outsource the entire business capability** | | | | | |
| | **RED** | **RED** | **RED** | **RED** | **RED** | **Rejected** |
| | | | • Wasted sunk cost in SAP Success Factors during RIIO-1<br>• | | | |
| New Platform | **This option would see the SAP Success Factors functionality moved to a competitor's platform following a competitive tendering process and a large scale multi-year programme to migrate data and processes.** | | | | | |
| | **RED** | **RED** | **RED** | **RED** | **RED** | **Rejected** |
| | | | • Wasted sunk cost in SAP Success Factors during RIIO-1<br>• | • | • Creates need for complex integrations with surround SAP landscape | |
| Maintain / Enhance | **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** |
| | | | • Exploits RIIO-1 investment<br>• Maintains security compliance<br>• Maintains compatibility with wider on premise and SaaS eco-systems | • Minor capability improvements advance the efficiency of operations | | |

## Digital and web applications

The following table describes the high-level options considered for this business theme.

| Option | * TCO over RIIO-2 | Capacity to Deliver | Business / Strategic Fit | Addressing the problem | Risk | Overall |
|---|---|---|---|---|---|---|
| Do nothing during RIIO-2 (no further maintenance/enhancement) and defer till T3 | **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** |
| | | | • | • No impact on improving efficiency<br>• Or stakeholder experience | • Health of the current solutions will continue to deteriorate and lead to further inefficiencies in operations | |
| Outsource | **This option is to completely outsource the entire business capability** | | | | | |
| | **RED** | **RED** | **RED** | **RED** | **RED** | **Rejected** |
| | | | • | | | |
| New Platform | **<<<?>>>>** | | | | | |
| | **RED** | **RED** | **RED** | **RED** | **RED** | **Rejected** |
| | | | • | | • | |
| Maintain / Enhance | **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** |
| | | | • | • | | |

## 6.11. Key assumptions and dependencies

### 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 n-1 policy remains in place for interoperability with connected SaaS solutions.

### Dependencies

- Reliance on the business change transformation agenda to align changes in business process, culture and behaviours to support development and use of new technology.
- Reliance on data enhancement strategy in parallel with new system and processes.
- Interdependency of systems due to the nature of a fully-integrated SAP centric landscape requiring alignment against vendor road maps

## 6.12. Conclusion

The proposed RIIO-2 investment in business services is carefully considered and well-balanced to continue to unlock efficiencies delivered in RIIO-1. The investments will deliver and support National Grid and the ESO in becoming a digital enterprise, driving efficiency benefits whilst ensuring the systems landscape remains current, preventing the accumulation of technical debt which would require significant major future investments.

This continuous innovation of our core support function systems, with continual patching and evolution approach, onto simple implementations not only helps National Grid to stay secure, but also ensures it benefits as the platforms evolve to give both internal and external compatibility of systems.

# 7. Shared investments: modern workspace

## 7.1. Executive summary

Modern workspace comprises traditional end-user computing, printing, and the new digital workplace, to provide fast, frictionless, end user services.

Modern workspace provides all employees, contractors and partners with a reliable, secure and high-performing work environment that supports National Grid's 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 isconvenient, fast and frictionless.

Modern workspace 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 performance which results in cost reductions for consumers.

**An investment by the group of £26.3 million (£8 million allocation for ESO) across the RIIO-2 period is required to refresh and enhance assets that deliver these services.**

The asset policies that underpin these investments and the level of investment required were compared with Gartner, a recognised expert in technology benchmarking. Gartner[2] indicates the asset health policies are in line with industry practice, and the value of investment is within the benchmark range.

## 7.2. Introduction

National Grid is undergoing a technological and digital transformation, driven by our vision of exceeding the expectations of our customers, stakeholders, and 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.[3]

As we start to transition from the older Microsoft Windows 7 platform to the newer Microsoft Windows 10 platform, we are seeing improvements in start-up time from an average of 180 seconds to 30 seconds. Scaled across 9,000 users, 220 working days, average hourly cost of £35, discounted 50 per cent (not all the time saved will result in more work) this equates to annual savings of £1.4 million or £7.4 million over the RIIO-2 period.

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

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

The modern workspace investment covers three main themes:

- Modern workspace 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 collaboration and communication.
- Emerging technologies – programme of work to analyse and implement as appropriate disruptive/new technologies.

## 7.3. Background information

### Delivery model

National Grid 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.

## 7.4. Overview of investments

### Modern workplace end-user service (Group investment - £21.7 million)

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 (Group investment - £15.2 million):

During the RIIO-1 period, devices have been replaced based on service failure, on average after four – 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 productivity for users of devices four years and older. Examples of this are extended log-in times, poor performance with shared documents etc. 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 annum) as a continuous program of work (rather than discrete projects as previously).

This has been benchmarked by Gartner Research[4] 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 (Group investment - £2.5 million):

An ongoing programme to support refreshes and upgrades of core services e.g. Microsoft O365 and Windows 10 is 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.[5]
- 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 (currently National Grid 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) (Group investment - £4.0 million)

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

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

### Unified communications and collaboration (Group investment - £3.1 million)

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 (Group investment - £2.5 million):

National Grid 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 (Group investment - £1.6 million):

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 (Group investment - £0.5 million)

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.

## 7.5. 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 5 years | Green<br>Minimal outlay | Red<br>Aged device estate already causing significant disruption to business | Red<br>Devices unable to support new technology, hinder ability to exploit value from new technology | Red<br>Does not address end-user experience and performance issues | Red<br>The rapid evolution of new technology increasingly makes older environments obsolete and unsupported. This poses a risk to cybersecurity, resilience and efficiency. | Not viable/rejected |
| Refresh over 3 years | Green<br>Ensures best value between staying modern while leveraging asset. In line with Gartner “mainstream” recommendation | Green<br>New MWS contract structured to give rolling upgrade of devices | Green<br>Devices replaced every 3 years in line with policy. All devices are maintained to current operating systems, receive ongoing security patches and deliver good performance | Green<br>Ensures improvement to end-user experience and performance, and supports introduction of new technologies | Green<br>Security reliability and performance risks mitigated | Viable / Recommended |
| Refresh over 4 years | Amber<br>While within Gartner two-to four-year recommendation would require higher spec devices with higher initial cost | Green<br>New MWS contract structured to give rolling upgrade of devices | Green<br>All devices are maintained to current operating systems, receive ongoing security patches and deliver reasonable performance | Green<br>Ensures improvement to end user experience and performance, and supporting introduction of new technologies | Green<br>Security reliability and performance risks mitigated | Viable/rejected |

## 7.6. Key assumptions, risk and contingency

| Risk | 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 don't 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 |

## 7.7. 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 National Grid and ESO business operations by maintaining high-levels of productivity.

# 8. Shared investments: hosting

## 8.1. Executive summary

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

At the beginning of the RIIO-1 period, we responded to the challenge from Ofgem 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 £80 million as a group (£37.2 million allocation for ESO) over the RIIO-2 period.**

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 across the National Grid group, we need to completet IT hosting infrastructure modernisation programme started during the RIIO-1 period. Across the operational businesses we see a range of initiatives to improve the transparency and availability of data for both customers and stakeholders, to provide operational tools and applications that underpin efficient operations and to enable the adoption of processes that continue to support the safe, reliable and efficient operation of the energy systems. Failure to invest in the IT foundations that support all these investments would constrain the outcomes and limit the benefits, impacting cost and efficiency across the entire organisation.

## 8.2. 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. All 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 National Grid, 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 extend the life of key IT assets beyond our existing asset health policy. We responded to the challenge by extending the technical lives of our IT infrastructure assets, accepting higher levels of risk whilst maintaining availability.

As we continued through RIIO-1, our employees fed back that 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 the National Grid IT hosting assets at or beyond end of life, putting us at risk from increasing probability of failure, we have re-examined our asset health policies for the underpinning infrastructure supporting our businesses operations. This has

led to increased spending on IT hosting technologies, mitigating risk, driving improved operational performance and reducing cost.

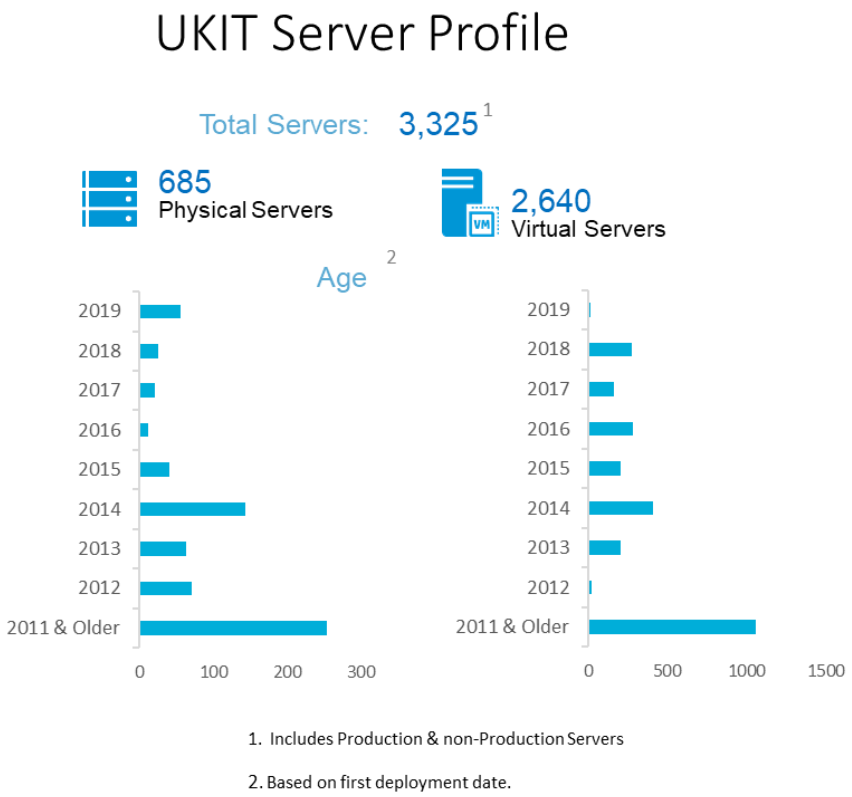


*Figure 62 – UK server ages*

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

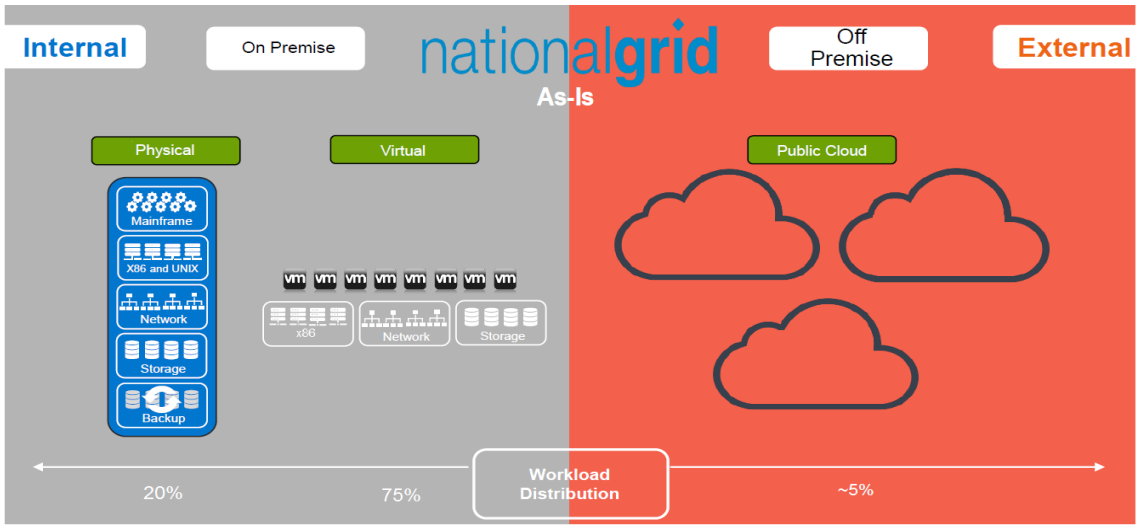


*Figure 63 – Current workload distribution across cloud offerings*

The energy sector's move to zero carbon is bringing a period of unprecedented change. National Grid 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 eco-system 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 National Grid. 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 from operational platforms, from energy balancing and SCADA platforms, to analytical modelling such as digital twins 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 National Grid and the networks and markets it operates on behalf of the United Kingdom, 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 performance and in many cases completely block the adoption of best-in-class solutions.

## 8.3. 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 providing new assets to meet additional demand using recommended hardware specific to the application. (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 to be consistent, develop our hybrid and cloud capabilities for connectivity and integrate our framework.

### Evaluation criteria

The following options will be evaluated on the basis of 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 however 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 be meeting 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.

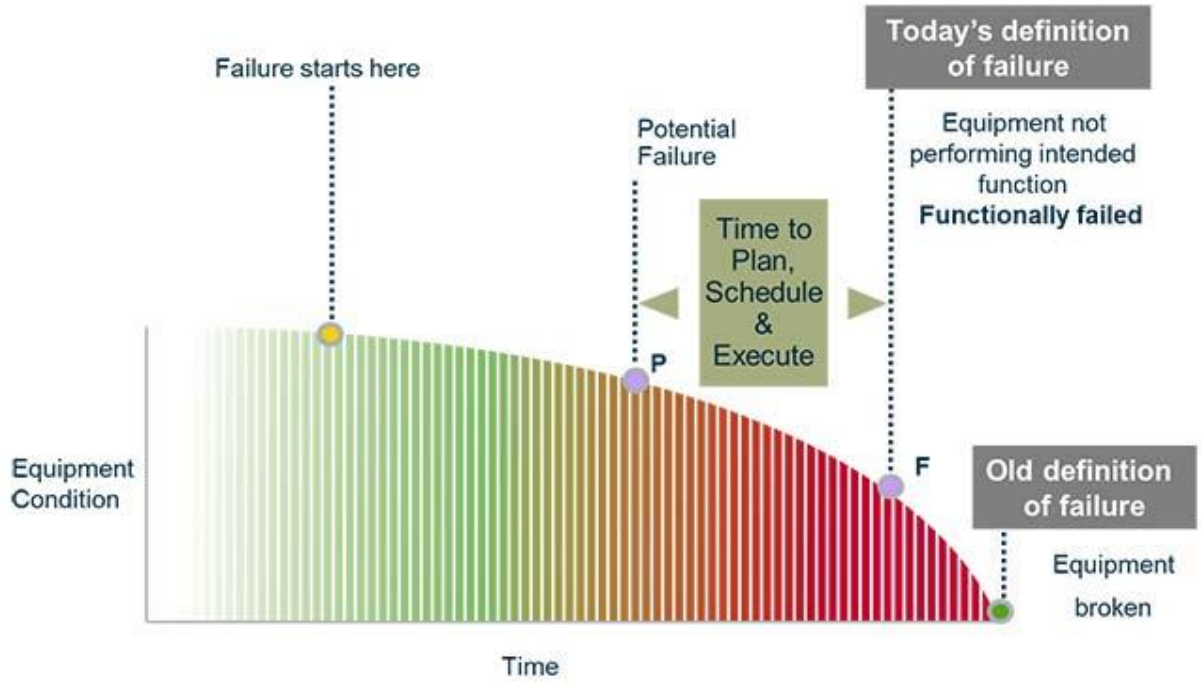


*Figure 64 – Equipment condition and relationship to failure over time*

## 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 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 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, so understanding 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 software as a service (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 of the are realised as soon as possible.

### Future requirements

Taking into account customer and stakeholder feedback, the operational requirements of the applications the RIIO-2 period 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 of solutions, including subscription-based services (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 increasingly 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 cost and performance objectives.

The investments 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 cost. The diagram below shows how workloads are planned across the hosting models through the RIIO-2 regulatory period.

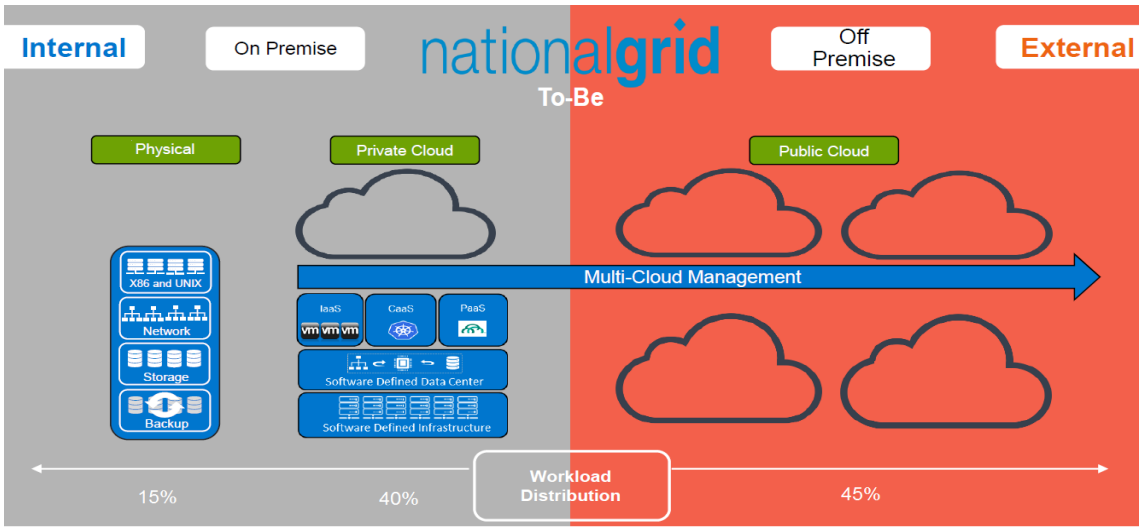


*Figure 65 – Future distribution workload across cloud offerings*

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.

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## Table of options considered

| Option | * Total Cost of ownership | Capacity to deliver | Business/strategic fit | Addressing the problem | Risk | Overall |
|---|---|---|---|---|---|---|
| Do nothing | **Red**<br>High contract and support costs are expected if contract renewal were optioned | **Green**<br>Use existing skills and resources. Current Contract with DXC expires in 2021 | **Red**<br>Unable to use leading industry solutions and ability to change and innovate severely impacted | **Red**<br>Does not address customer experience and resilience | **Red**<br>Costs to host and manage would increase significantly and high risk to service due to end of life hardware and software | Rejected |
| Fully outsource (SaaS & Public cloud) | **Red**<br>Highest cost | **Green**<br>External companies bring economies of scale, best in class services and innovation | **Green**<br>Minimal effort to run and maintain systems and ability to use leading edge services for rapid change and innovation | **Green**<br>Addresses customer experience, capacity and resilience requirements | **Red**<br>Costs would increase and be difficult to manage. Challenges with CNI workloads and alignment | Rejected |
| Fully insource (Private cloud) | **Green**<br>Higher costs of insourcing, training and operations | **Red**<br>Difficult to acquire skills rto build the environment. Time and resource requirements considerable for a full private cloud build | **Red**<br>Limits ability to leverage leading industry solutions and ability to change and innovate severely impacted | **Green**<br>Addresses the resilience problems but will have limitations in meeting customer needs | **Red**<br>Ability to acquire skills and build environment a major concern and being able to provide the required level of resilience and capacity | Rejected |
| Mature Hybrid (preferred option) | **Green**<br>Best cost profile | **Green**<br>Repurpose existing resource for new on-premise environments. Cloud services where appropriate using cloud vendors | **Green**<br>Enables the optimum balance of on premise and commodity services | **Green**<br>Addresses customer experience and resilience requirements | **Red**<br>Sub-optimal blend of cloud services and on-premise increases costs | Recommended |

## 8.4. 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.

| Investment Plan No. | Investment Title | 2022 | 2023 | 2024 | 2025 | 2026 | Total RIIO-2 |
|---|---|---|---|---|---|---|---|
| | Hosting | 19.9 | 17.9 | 9.7 | 8.5 | 8.5 | 64.5 |

*Figure 66 – RIIO-2 phased and total investment costs (£'million, 2018/19 prices)*

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 charge-back 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, National Grid 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.

## 8.5. Key assumptions, risks and contingency

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.

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

| Risk | 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 re-design 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 C&H delivery teams. |
| Age of current estate may make migrations challenging or unachievable. 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 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 |
| Lack of automation in provisioning; continued use of old ways of working 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 bring in key skills to meet future demand |
| Ability to host legacy applications/technologies. | Provision will be made in new contracts to allow for legacy systems. |

## 8.6. 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.

National Grid's strategy is to continue to mature our hybrid cloud model. We have started on 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,creating a cloud framework to guide execution. We will continue to build the architecture to enable our hybrid strategy, including connectivity and integration and will arrange services so they can be transitioned should their profile change.

# 9. Shared investments: enterprise data network

## 9.1. Executive summary

National Grid'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 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 for the wide area network (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 £29.5 million as a group (£18.2 million allocation for ESO) during the RIIO-2 period with early investment across all network services to maximise the benefits for customers and payback.**

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.

## 9.2. Introduction

Enterprise data network services enable connectivity (virtually transparent to the user) for virtually all IT activity. As with electricity, where we don't give a second thought to the fact the lights will come on when we flick the switch, it is the same with enterprise networks: we simply connect. However, 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.

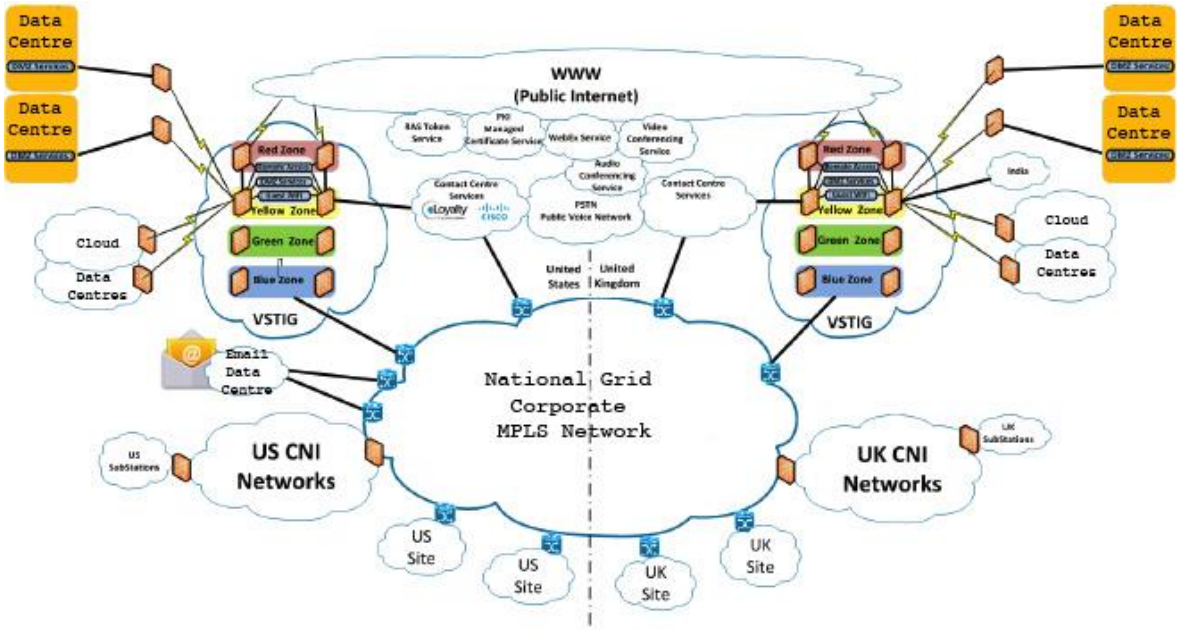



*Figure 67 – Enterprise network topology*

The scope of the network services are 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 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 | 342 UK sites<br>413 routers<br>primary/back-up<br>Capacity/bandwidth | Provides access to shared computing resources and applications. Supports 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.<br><br>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<br>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 | 6,000 user accounts | Reliable, high-quality voice services. In addition to individual |

| Network Service | Description | Volume | Value |
|---|---|---|---|
| | 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. | | 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. |

A diagrammatic representation of the National Grid WAN in the UK and global voice network is included below.

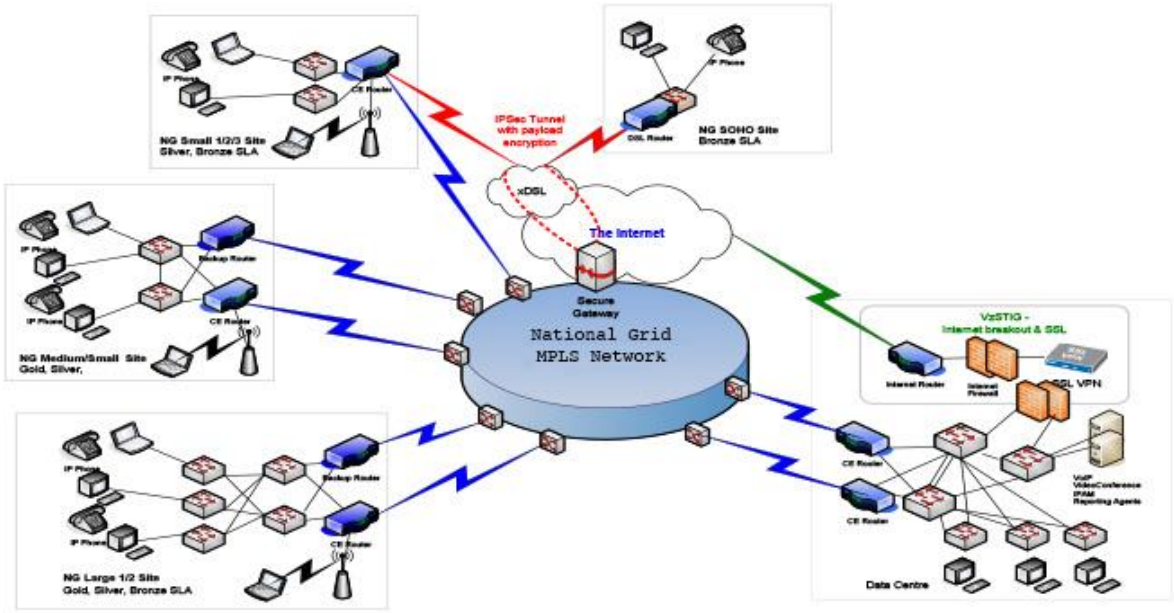



*Figure 68 – National grid wide area network (WAN) in the UK*

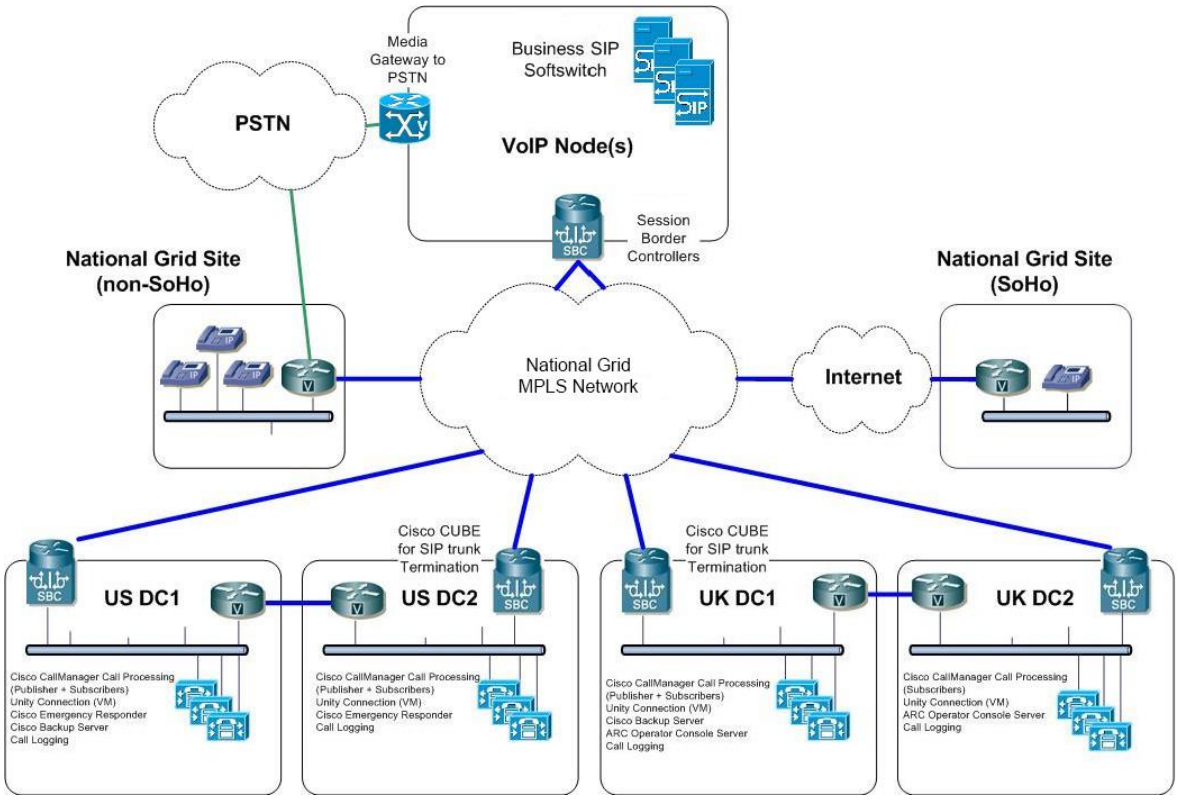



*Figure 69 – National Grid global voice network*

Failure of these services would severely impact the ability of National Grid 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..

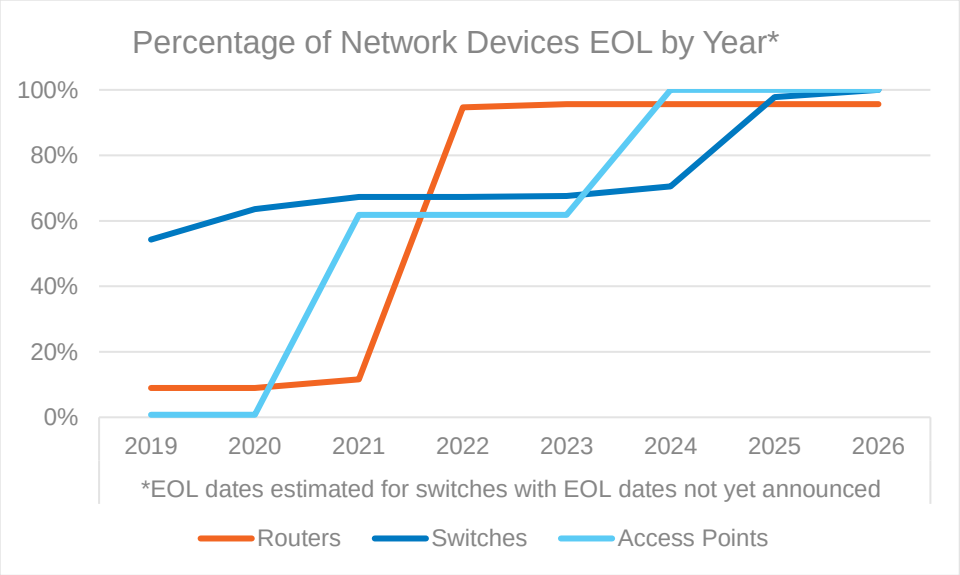



*Figure 70 – Network end-of-life (EOL) equipment timeline*

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.

## 9.3. RIIO-1 background information

At the start of RIIO-1, we responded to the challenge from Ofgem to reassess our IT asset health policies by extending the live of our IT infrastructure assets, accepting higher levels of risk whilst maintaining availability. This has led to higher risk of network outages, with over 300 network incidents with a severity of high or critical from since 2017. While consumers benefited from the deferral of this investment in our infrastructure, our aging IT infrastructure has begun to impact productivity.

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 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 IT has undertaken a detailed technical and cost benefit analysis and concluded a need to invest £8.93 million as a group in the WAN and £16.88 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 Expenditures 2015-2022 | RIIO-2 Expenditures 2022-2026 |
|---|---|---|
| WAN | £4.61m | £8.93m |
| LAN | £11.31m | £16.88m |

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.

## 9.4. 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 |
|---|---|---|---|---|---|---|
| **Option 1**<br>**Retain and upgrade existing network technologies**<br><br>**Replace network assets at EOL with schedule driven by asset refresh policy** | **Amber**<br>• Costs remain similar to today<br>• WAN costs for additional bandwidth drop over time<br>• Future large investment required to upgrade MPLS and VSTIG network to support cloud usage | **Green**<br>• Proven technology from the incumbent network providers.<br>• Use established industry standards, better understood to maintain and expand | **Amber**<br>• Supports today's short-term business requirements.<br>• Uses established technologies from multiple vendors<br>• Good availability of skills and knowledge internally to exploit | **Amber**<br>• Addresses the EOL problem with hardware support and compliance<br>• Addresses part of the problem with the underlying migration to cloud services.<br>• Does not address large-scale move to cloud and use of SaaS applications. | **Green**<br>• Removes risks around EOL infrastructure<br>• Proven technology from incumbent network providers.<br>• Supports short-term business requirements | **Rejected**<br>• Provides a supportable and maintainable version of the current technology but does not position for future business requirements. |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Option 2**<br>**Migrate WAN to and SD WAN architecture to realise cost savings and performance improvements (through policy-based traffic routing) over three years** | **Amber**<br>• Opportunity to replace MPLS links with internet to reduce WAN charges<br>• Implementation of multiple access methods (MPLS and internet) at sites may result in increased WAN charges<br>• Local internet services will reduce the cost of future VSTIG infrastructure upgrades | **Green**<br>• Initial SD WAN and cloud-based security deployments are under way<br>• Use of market-leading SD WAN software and trusted virtual computing platforms will support the delivery of a reliable solution<br>• Internet provides access to cloud services without being constrained by WAN and internet bandwidth<br>• Virtual routers are capable of additional functions | **Green**<br>• Supports current and future business requirements<br>• Supports move to cloud services<br>• Supports user mobility and collaborative working<br>• Reduces the need to upgrade VSTIG internet bandwidth | **Green**<br>• Addresses problem of underlying hardware being supported<br>• Addresses the problem of increased use of cloud services.<br>• Addresses the problem of the increased WAN bandwidth requirements<br>• Address the problem of VSTIG bandwidth being risky and expensive to upgrade | **Amber**<br>• New technology and virtual routing devices have a higher configuration complexity than traditional network devices<br>• Removes risks around EOL infrastructure in the NG environment<br>• Removes risk of bandwidth capacity for private and cloud services | **Green**<br>• Meets current and known business requirements<br>• Provides greater control of applications and bandwidth use<br>• Maintains security |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Option 3**<br>**As per option 2 plus –**<br><br>**Accelerated SD WAN schedule over 1 year** | **Red**<br>• Opportunity to replace MPLS links with internet to reduce WAN charges<br>• Implementation of multiple access methods (MPLS and internet) at sites may result in increased WAN charges<br>• Local internet services will reduce the cost of future VSTIG infrastructure upgrades<br>• Delivery in one year may not be fiscally prudent | **Red**<br>• Accelerated timeline may overtax National Grid and 3rd party suppliers<br>• Less time to analyse services during delivery that could improve solution<br>• Initial SD WAN and cloud-based security deployments are under way<br>• Use of market-leading SD WAN software and trusted virtual computing platforms will support delivery of a reliable solution. | **Green**<br>• Meets our goals faster than Option 2<br>• Supports current and future business requirements<br>• Supports move to cloud services<br>• Supports user mobility and collaborative working<br>• Reduce the need to upgrade VSTIG internet bandwidth | **Green**<br>• Addresses the problem of underlying hardware being supported<br>• Addresses the problem of increased use of cloud services<br>• Addresses the problem of increased WAN bandwidth requirements<br>• Address the problem of VSTIG bandwidth being risky and expensive to upgrade | **Amber**<br>• Accelerated timeline may overtax National Grid and 3rd party suppliers<br>• New technology and virtual routing devices have a higher configuration complexity than traditional network devices<br>• Removes risks around EOL infrastructure Removes risk of bandwidth capacity for cloud services | **Rejected**<br>• Delivery in one year may not be fiscally prudent<br>• Meets our goals faster than Option 2<br>• Accelerated timeline may overtax National Grid and 3rd party suppliers |

Option one 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.

Options two and three 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 904 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 l desk phones. Due to this requirement, 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 |
|---|---|---|---|---|---|---|
| **Option 1**<br>**Upgrade LAN to high density Wi-Fi (overwise will need more office space)**<br><br>**Replace network assets at EOL with schedule driven by asset refresh policy** | **Amber**<br>• Does not align with LAN refresh schedule to support switch port reductions<br>• WLAN charges will increase with additional WAPs<br>• Migration to an alternate Wi-Fi hardware manufacturer will reduce capex and RTB costs | **Green**<br>• Proven Technology from the incumbent network providers<br>• Adoption of established Industry Standards, better understood to maintain and expand. | **Green**<br>• Supports most of today's business requirements but may not deliver required availability<br>• Uses established technologies from mature vendors<br>• Good availability of skills and knowledge internally to exploit | **Amber**<br>• Addresses the problem with Wi-Fi and the need to support collaboration, flexible work styles and office hoteling<br>• Asset refresh schedule will not meet business need for improved services<br>• Wi-Fi is a more complex environment and lack of network redesign and automation and Wi-Fi management tools could result in increased outages | **Amber**<br>• Removes risks around EOL infrastructure in the NG environment<br>• Proven Technology from incumbent network providers<br>• Supports most short-term business requirements<br>• Introduces operational risk of large-scale Wi-Fi environment without proper management tools | **Rejected**<br>• Provides the Wi-Fi capability required but does not address potential cost increases of operating both a fully-wired and wireless LAN.<br>• Does not take advantage of potential cost reductions from a LAN redesign (e.g. capex savings with alternate hardware, opex reductions through automation and support process improvements) |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Option 2**<br>**As per Option 1 plus –**<br><br>**LAN redesign to reduce RTB over five years** | **Green**<br>• Reduction in switch ports will reduce LAN costs<br>• Automation of LAN provisioning will reduce support costs and restoration time<br>• Implementation of management and performance tools will identify issues and reduce outages<br>• Migration to an alternate Wi-Fi hardware manufacturer will reduce capex and opex run costs | **Green**<br>• Proven technology from incumbent network providers<br>• Adoption of established Industry Standards, better understood to maintain and expand | **Green**<br>• Delivers a supportable environment to meet business requirements<br>• Improves the time to deliver services<br>• Uses established technologies from mature vendors<br>• Good availability of skills and knowledge internally to exploit | **Amber**<br>• Addresses business need to deliver a high performing Wi-Fi environment to support collaboration, flexible work styles and office hoteling<br>• Five-year schedule delays the benefit of the network redesign<br>• Delivers the required improvements to the LAN and associated management tools to provide proper support to the environment | **Green**<br>• Removes risks around EOL infrastructure<br>• Proven technology from incumbent network providers<br>• Supports most business requirements | **Green**<br>• Provides a fully supported LAN/ Wi-Fi environment with the proper design and operational tools and processes<br>• Five-year time frame allows for assets to depreciate but delays the delivery of service and cost benefits |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Option 3**<br>**As per Option 2 plus -**<br><br>**LAN redesign to reduce RTB over 3 years** | **Red**<br>• Replaces assets before they are fully depreciated<br>• Reduction in switch ports will reduce LAN costs<br>• Automation of LAN provisioning will reduce support costs and restoration time<br>• Implementation of management and performance tools will identify issues and reduce outages<br>• Migration to an alternate Wi-Fi hardware manufacturer will reduce capex and opex run costs | **Green**<br>• Proven technology from incumbent network providers<br>• Adoption of established Industry Standards, better understood to maintain and expand | **Green**<br>• Delivers a supportable environment capable of meeting business requirements<br>• Improves the time to deliver services<br>• Uses established technologies from mature vendors<br>• Good availability of skills and knowledge internally to exploit | **Green**<br>• Addresses business need to deliver a high performing Wi-Fi environment to support collaboration, flexible work styles and office hoteling<br>• Three-year schedule better meets the need of the business and opportunities for savings<br>• Delivers the required improvements to the LAN and associated management tools to provide proper support to the environment | **Green**<br>• Removes risks around EOL infrastructure<br>• Proven technology from incumbent network providers<br>• Supports most near-term business requirements<br>• Introduces operational risk of large-scale Wi-Fi environment without proper management tools | **Rejected**<br>• Replaces assets before they are fully depreciated<br>• Provides a fully supported LAN/ Wi-Fi environment with the proper design and operational tools and processes.<br>• Three-year schedule better meets the need of the business and opportunities for savings |

*Figure 71* – table examines the options available for the enterprise local area and Wi-Fi network

Option one 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 improved management capability.

Option 2 and Option 3 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.

## 9.5. 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.

Our proposed investment for WAN and LAN are detailed in the table below, showing the phased and total investment cost for RIIO-2 period (£ million, 2018/19 prices), capex and opex shown separately.

Capex

| Investment Plan No. | Investment Title | 2021/22 | 2022//23 | 2023/24 | 2024/25 | 2025/26 | Total RIIO-2 |
|---|---|---|---|---|---|---|---|
| INVP 4876 | WAN infrastructure | 1.92 | 2.16 | 1.92 | 1.34 | 1.58 | 8.93 |
| INVP 4868 | LAN infrastructure | 2.82 | 2.26 | 2.15 | 2.88 | 2.26 | 12.38 |
| TBD | RIIO-2 Voice Infrastructure | 1.5 | 1.5 | 0.5 | 0.5 | 0.5 | 4.5 |
| | | | | | | | |
| Total Capex | | 6.24 | 5.92 | 4.57 | 4.72 | 4.34 | 29.55 |

Project opex

| Investment Plan No. | Investment Title | 2021/22 | 2022/23 | 2023/24 | 2024/25 | 2025/26 | Total RIIO-2 |
|---|---|---|---|---|---|---|---|
| INVP 4876 | WAN infrastructure | 0.4 | 0.4 | 0.4 | 0.1 | 0.1 | 1.4 |

## 9.6. Key assumptions, risk 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 option 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.

## 9.7. 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: (1) a network refresh to ensure the secure operation of the services is essential to the health of the business and (2) 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 and routing hardware. 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.

# 10. 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 | - | 1.7 | 1.9 | 2.1 | 2.1 | 7.7 |
| 140 | ENCC operator console | 1 | - | 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 | - | 0.4 | 0.8 | 1.2 | 1.6 | 4.0 |
| 200 | Future training simulator and tools | 1 | - | - | 1.5 | 2.9 | 2.9 | 7.3 |
| 210 | Balancing asset health | 1 | 1.4 | 1.4 | 1.4 | - | - | 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 | - | 7.0 |
| 260 | Forecasting enhancements | 1 | - | 0.5 | - | 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 |
| 290 | Charging and billing asset health | 2 | 3.0 | - | - | - | 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 | - | - | 0.5 | 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 |

| ID | Title | Theme | 2021/22 | 2022/23 | 2023/24 | 2024/25 | 2025/26 | Total |
|---|---|---|---|---|---|---|---|---|
| 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 | - | - | 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 | - | - | 5.0 |
| 490 | Support CATO tender process | 3 | 0.3 | 0.2 | - | - | - | 0.5 |
| 500 | Zero carbon operability | 4 | 4.4 | 5.8 | 7.8 | 4.4 | 2.5 | 24.9 |
| 510 | Restoration decision support | 1 | - | 0.5 | 1.5 | 2.0 | 1.0 | 5.0 |

# 11. Appendix B: 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 | 490 - Support CATO tender process | 500 - Zero carbon operability | 510 - Restoration decision support |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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

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 | 490 - Support CATO tender process | 500 - Zero carbon operability | 510 - Restoration decision support |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Build the future balancing service and wholesale markets | 8 | Create a single, integrated platform for ESO markets. This one-stop-shop will provide a platform to participate in all our balancing service markets and the Capacity Market, and give access to both historical and forecast data to support investment cases and decision-making. It will be expanded as other markets develop to allow the integration and data sharing required to enable efficient decisions to be made across markets. | | | | | | | | | | | ■ | | ■ | | | | ■ | | | | | | | | | ■ | | ■ | | | | | |
| | 9 | Develop and implement a single day-ahead auction for response and reserve products. This will take into account the impact on distribution system operation when this information becomes available. | ■ | | | | ■ | | ■ | | | | ■ | | ■ | | | | | | | | ■ | ■ | | | | ■ | ■ | ■ | | ■ | | | |
| | 10 | Work collaboratively with the Distribution Network Operators (DNOs), sharing necessary data and bringing our expertise to bear alongside theirs, to accelerate development of markets at distribution level. We will design our systems to integrate this data into our electricity control room processes, and the cost signals that these markets provide will allow the ESO to take a whole system view when making decisions. | | | | | ■ | | ■ | | | | ■ | | | | | | | | | | ■ | ■ | | | | | | | | | | | |
| | 11 | Develop and run a sandbox experimental market environment, alongside our established markets, to test ideas such as a system inertia market, promote new entrants and ultimately drive down costs to consumers. | | | | | | | ■ | | ■ | | ■ | | | | | | | | | | | | | | ■ | ■ | ■ | | | ■ | | | |
| | 12 | Design the markets of the future; step up to lead a review of wholesale and balancing markets, delivering a new design by 2023, working closely with all stakeholders. Key considerations will include gate closure period, length of balancing period and the impact of large volumes of zero marginal cost generation on efficient market design. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Transform access to the Capacity Market | 13 | Deliver a new platform for the Capacity Market within the single, integrated ESO markets platform. This platform will improve the experience for participants. Artificial intelligence will be used to help participants understand how they can participate in the Capacity Market and will guide them through the process. | | | | | | | | | | | ■ | | ■ | | | | | | | | | | | | | ■ | | ■ | | | | | |
| | 14 | Take on responsibility for the development and management of the Capacity Market Rules. The principles of the code governance review will be used to make the rules clear, proportionate and equitable. There will be a clear roadmap for change, which will be developed through industry engagement. | | | | | | | | | | | | | ■ | | | | | | ■ | ■ | | | | | | | | | | | | | |
| | 15 | Improve our modelling capability to provide world-leading security of supply modelling for a system with significant levels of intermittent renewables, distributed flexible generation and demand-side response. This will be used together with detailed, granular data to determine the optimal volume of capacity to purchase. | | | | | | | | | | | ■ | | | | | | | | | | | | | | | | | | | | | | |
| Develop codes and charging arrangements that are fit for the future | 16 | EU Code change and relationships | ■ | | | | | | ■ | | | | ■ | | ■ | | ■ | | | | | | | | | | | | | | | | | | |
| | 17 | Code management / market development and change | ■ | | | | | | ■ | | | | ■ | | ■ | | | ■ | | | | | | | | | | | | | | | | | | |
| | 18 | Industry revenue management | | | | | | | | | | | | | ■ | | | | ■ | ■ | | | | | | | | | | | | | | | | |
| | 19 | Work with all stakeholders to create a fully-digitised, whole-system Grid Code by 2025 | | | | | | | | | | | | | ■ | | | | | | | ■ | | | | | | | | | | | | | |

## 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 | 490 - Support CATO tender process | 500 - Zero carbon operability | 510 - Restoration decision support |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 490 - Support CATO tender process | 500 - Zero carbon operability | 510 - Restoration decision support |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 490 - Support CATO tender process | 500 - Zero carbon operability | 510 - Restoration decision support |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | | | | | | | | | | | ■ | | | ■ | | | | | | | | | | | | | | | | | | | |

# 12. Appendix C: 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.

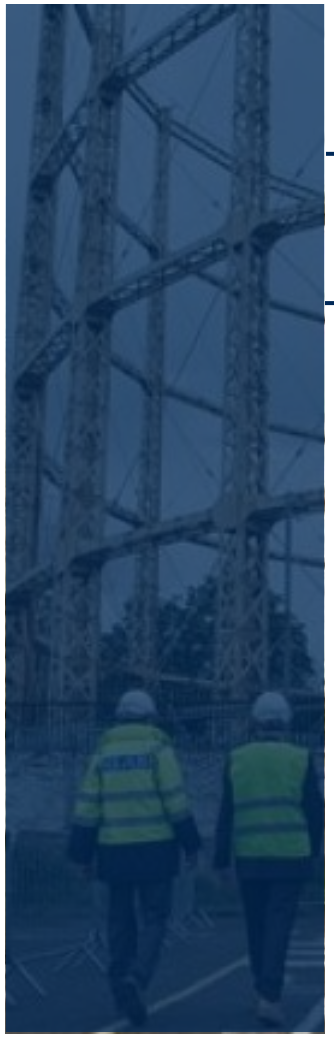
# RIIO 2 IT Benchmark Draft Report
## (Investment Assessment ESO only)

Tuesday 23rd July 2019

nationalgrid

Gartner®

# Contents





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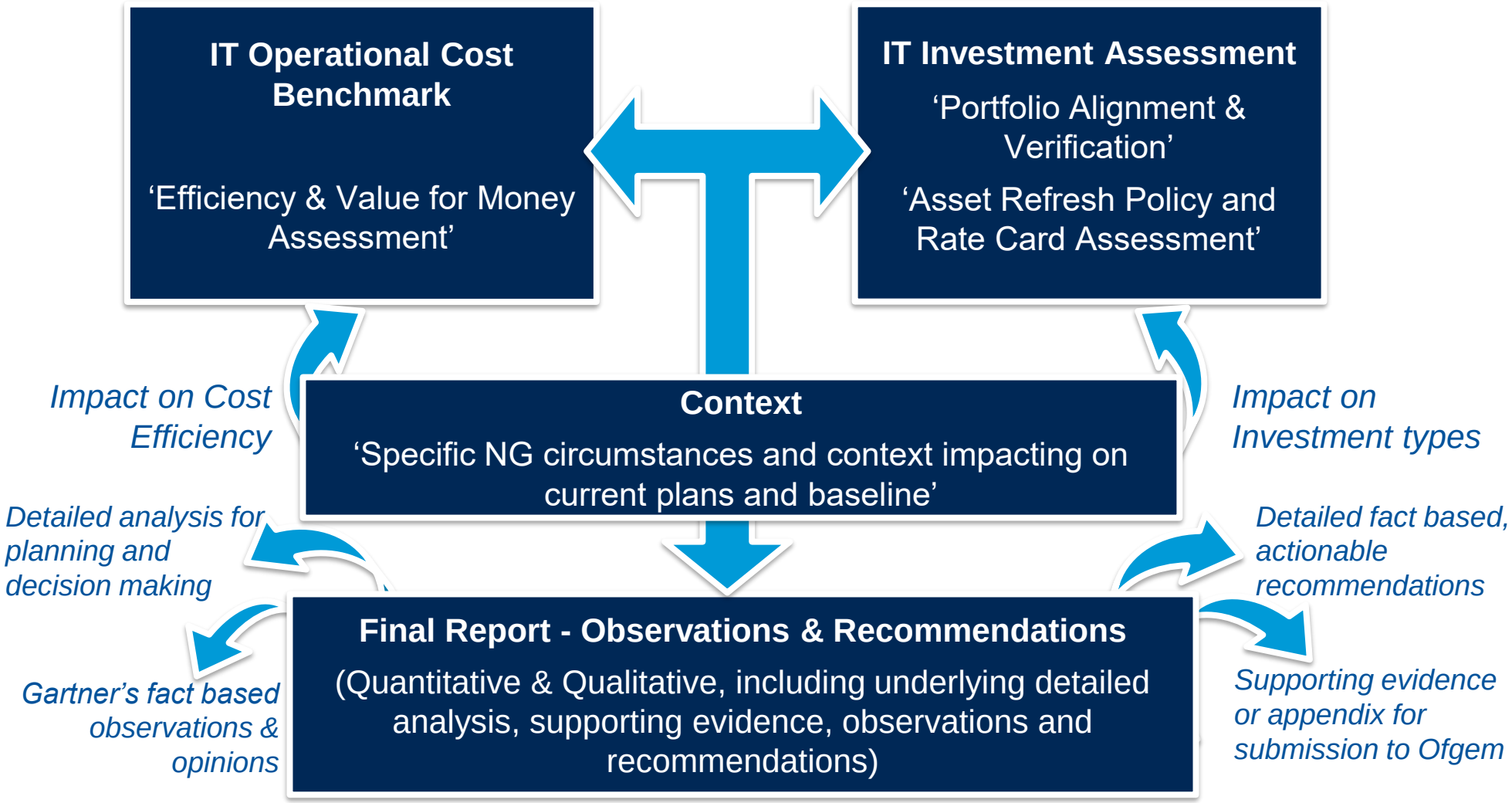
# 1. IT Investment Assessment (RIIO 2)

# Overview

# Overall Approach

**The engagement involved two workstreams, the first, a cost benchmark using 2018/19 as a baseline, the second an assessment of planned IT investments in RIIO T2 for each portfolio. The focus of this report is on the latter.**





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# IT Investment Assessment – Approach

**Gartner takes different approaches depending on the specific characteristics of each investment**

## Approach

- Across the investment portfolio as a whole, a number of different approaches are taken to benchmarking individual line items, as we take 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, we 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.
- Note that the ESO portfolio was reviewed twice by Gartner. This report reflects the findings from the second review.

# IT Investment Assessment – Assumptions

**The following assumptions were made when undertaking the assessment**

## Assumptions

- RIIO2 five year period is 2021/22 to 2026/27.
- Grouped into seven distinct portfolios: Business Services and Finance,  DRSS (IT Security), ESO, ETO, GSO, GTO and IT Infrastructure.
- As the investment portfolio was changing throughout the engagement, the portfolios as of 7 February were used as the basis of the assessment. The key exceptions were Business Services and Finance, were a second iteration was accepted on 5 April and ESO, where a third iteration is being reviewed.
- 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. In other recent Utilities assessments Gartner has seen a range of 3% to 6% in this area.

# ESO

**Proposed Investment: £409.6M**
**Gartner “Low” range: £295.9M**
**Gartner “High” range: £430.3M**
**Observation: Within range**




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# IT Investment Analysis (in £M)

## ESO

| ID | Initiative | NG Proposed | Gartner "Lower" | Gartner "Higher" | Variation | Gartner Comments |
|---|---|---|---|---|---|---|
| 110 | Network control | 25.00 | 20.00 | 35.00 | | The Gartner analysis is based on observed spend for similar projects world wide in other organisations. This analysis assumes connection to transmission operator Scada systems. Includes visualisation and alert management for overall GB electricity system and ability to send actions to substations or Scada systems |
| 120 | Interconnectors | 5.50 | 4.27 | 5.03 | 9% | Gartner has assessed this by reflecting change requirements to existing systems and enhancements to derive applicable FP range plus NG view of interconnector cost (£0.9k) |
| 130 | Emergent technology and system management | 7.70 | 5.00 | 8.00 | | Based on similar whole system management projects (monitoring and alerting, process monitoring, forecasting etc.) in range of around 5,000-8,000 FP. Given that the data platform and integration layer (with complex systems) needs to be developed higher end of the range is more likely. The Gartner analysis is reflects a cost per FP for complex incident tracking systems, system management projects (including forecasting components) |
| 140 | ENCC operator console | 5.50 | 2.00 | 5.50 | | This is historically bound to proprietary IEMS. Future visualisation initiatives may allow move to more commodity services. Based on historic costs which Gartner views a reasonable but should also take into count that equivalent technology is likely to be cheaper in the future. Gartner has observed planned control room spend in other organisations of £2m - £5m but functionality requirements could vary. Here we are using £2m as the low and the NG estimate as the high value for the range |
| 150 | Operational awareness and decision support | 12.30 | 15.00 | 20.00 | -18% | Gartner analysis assumes near real time state estimation, additional ML capability on top of optimisation and modelling, stability analysis, contingency analysis again near real time. Real time streaming data processing, assuming a complete new architecture and all the data platform is excluded from this investment. Getting a similar system from SCADA provider would typically be £15m-£20m |
| 170 | Frequency visibility | 3.10 | 1.60 | 1.92 | 63% | This is based on a number of large real-time monitoring system projects - around 3,200 FPs and applicable cost per FP range. The NG requirements refer to servers and data bases which suggests the £3m may not be unreasonable |
| 180 | Enhanced balancing capability | 45.00 | 27.00 | 44.00 | 2% | Based on Balancing System with Digital Twin and Simulation; Digital Twin is a fairly new concept in Energy Sector so the inclusion of this is based on relatively limited comparative data |

# IT Investment Analysis (in £M)

## ESO

| ID | Initiative | NG Proposed | Gartner "Lower" | Gartner "Higher" | Variation | Gartner Comments |
|---|---|---|---|---|---|---|
| 190 | Workflow and change management tools | 5.00 | 4.00 | 6.00 | | Based on smaller identity management projects, software management & admin, employee roster SW and change management, includes assumed decommissioning of old systems |
| 200 | Future training simulator and tools | 7.28 | 4.03 | 8.06 | | Future innovation / AI investments have been consolidated in a single "bucket" as Gartner typically sees 3% - 6% of overall investment spend in this area |
| 210 | Balancing asset health | 4.30 | 1.44 | 4.50 | | Based on the assumption that this reflects maintenance requirements of existing functionality, the NG value 9% of dev project (ID 180) is not unreasonable. The Gartner range reflects the 9% applied to the Gartner range for ID 180 |
| 220 | Data and analytics platform | 33.30 | 23.00 | 27.63 | 20% | Gartner analysis is based spend on data analytics platforms with additional bespoke analytics. The Gartner analysis excludes additional network connectivity (links to new participants and integration networking) – this will contribute to the gap to the Gartner range |
| 240 | ENCC asset health | 14.56 | 14.56 | 14.56 | | This is essentially miscellaneous allocation funding of niche IT systems based on historic costs. In the absence of any available comparative data Gartner view this as a reasonable basis for spend estimation |
| 250 | Digital engagement | 7.00 | 6.20 | 11.10 | | Based on multi-channel portal projects reflecting increased scope, including identity management and policy enforcement capability. The Gartner range reflects that this could be across multiple systems |
| 260 | Forecasting enhancements | 3.30 | 1.83 | 3.67 | | Future innovation / AI investments have been consolidated in a single "bucket" as Gartner typically sees 3% - 6% of overall investment spend in this area |
| 270 | EU regulation | 43.00 | 30.09 | 43.00 | | When comparing NG's planned spend for regulatory requirements to what Gartner sees in other DNOs, NG appears to be significantly higher. We've typically seen less than 5% of planned capital investment compared to 17% for NG. Other survey data Gartner has reviewed shows an expected spend of 12-14% of IT budget on regulatory compliance. Taking into account NG's complexity and that planned spend is based on previous spend NG's value would not be unreasonable |

# IT Investment Analysis (in £M)

## ESO

| ID | Initiative | NG Proposed | Gartner "Lower" | Gartner "Higher" | Variation | Gartner Comments |
|---|---|---|---|---|---|---|
| 280 | GB regulation | 15.00 | 10.50 | 15.00 | | When comparing NG's planned spend for regulatory requirements to what Gartner sees in other DNOs, NG appears to be significantly higher. We've typically seen less than 5% of planned capital investment compared to 17% for NG. Other survey data Gartner has reviewed shows an expected spend of 12-14% of IT budget on regulatory compliance. Taking into account NG's complexity and that planned spend is based on previous spend NG's value would not be unreasonable |
| 290 | Charging and billing asset health | 5.10 | 5.00 | 8.33 | | Gartner sees settlement systems in 5-10M USD range. The Gartner validation reflects that NG is subject to multiple regulations and when replacing the system some additional processes need to be implemented (previously completed manually and/or outside the existing system) and the modularity requirement |
| 300 | Charging regime and CUSC changes | 4.50 | 3.11 | 3.63 | | When comparing NG's planned spend for regulatory requirements to what Gartner sees in other DNOs, NG appears to be significantly higher. We've typically seen less than 5% of planned capital investment compared to 17% for NG. Other survey data Gartner has reviewed shows an expected spend of 12-14% of IT budget on regulatory compliance. Taking into account NG's complexity and that planned spend is based on previous spend NG's value would not be unreasonable |
| 320 | EMR & CFD improvements | 7.80 | 5.46 | 7.80 | | When comparing NG's planned spend for regulatory requirements to what Gartner sees in other DNOs, NG appears to be significantly higher. We've typically seen less than 5% of planned capital investment compared to 17% for NG. Other survey data Gartner has reviewed shows an expected spend of 12-14% of IT budget on regulatory compliance. Taking into account NG's complexity and that planned spend is based on previous spend NG's value would not be unreasonable |
| 330 | Digitalised code management | 2.60 | 1.44 | 2.88 | | Basically AI therefore AI investments have been consolidated in a single "bucket" as Gartner typically sees 3% - 6% of overall investment spend in this area |
| 340 | RDP implementation and extension | 17.30 | 17.30 | 17.30 | | This is a 'bucket of spend' for future RDPs based on previous spend. Since each RDP can have different functionality and purpose it is no possible to estimate future spend but using previous spend as a basis would seem to be reasonable |

# IT Investment Analysis (in £M)

## ESO

| ID | Initiative | NG Proposed | Gartner "Lower" | Gartner "Higher" | Variation | Gartner Comments |
|---|---|---|---|---|---|---|
| 350 | Planning and outage data exchange | 7.80 | 5.00 | 6.20 | 26% | Based on top end Portal projects with integration / web services for data transfer, taking into account multiple channels of information as well as forecasting/planning, visualisation, interaction with other tools, etc. (size estimate is approx 6,000 FPs) |
| 360 | Offline network modelling | 11.40 | 4.14 | 12.00 | | This is based on expected spend for new development of comprehensive, large (around 12k FP) offline network modelling and deeper outage planning system taking into account realtime analysis and zero carbon requirements |
| 380 | Connections portal | 3.00 | 2.00 | 5.00 | | This is based on a range of Portal projects with varying functionality requirements. Assuming additional functionality is required over time, planned spend towards the high end of the range would seem reasonable |
| 390 | NOA enhancements | 15.10 | 8.00 | 16.00 | | Gartner range is based on expected spend on multiple investment planning / modelling / optimisation tools for Energy Sector reflecting complexity, data availability (real-time, etc.), integration, plus refresh |
| 400 | Markets platform | 18.30 | 14.00 | 20.00 | | Based on observed spend on large CRM and similar projects - including Portals - , taking into account API, integration and sandbox functionality requirements |
| 410 | Ancillary services settlements refresh | 5.60 | 1.60 | 4.10 | 36% | This is based Application Support projects (not new development) for fairly large Billing Systems (with national reach) in the database suggest that the total cost could be between £1.6m and £4.1m. The range reflects the unknown level of changes required and complexity. The NG value reflects some changes in project phasing with some T1 planned investment going into T2 – this contributes to the gap to the Gartner range |
| 420 | Ancillary service auction capability | 8.00 | 4.17 | 8.33 | | Gartner price based on provision of portals and auctioning functionality, including real-time operation and integration |
| 450 | Future innovation productionisation | 9.00 | 4.98 | 9.97 | | Future innovation / AI investments have been consolidated in a single "bucket" as Gartner typically sees 3% - 6% of overall investment spend in this area. |

# IT Investment Analysis (in £M)

## ESO

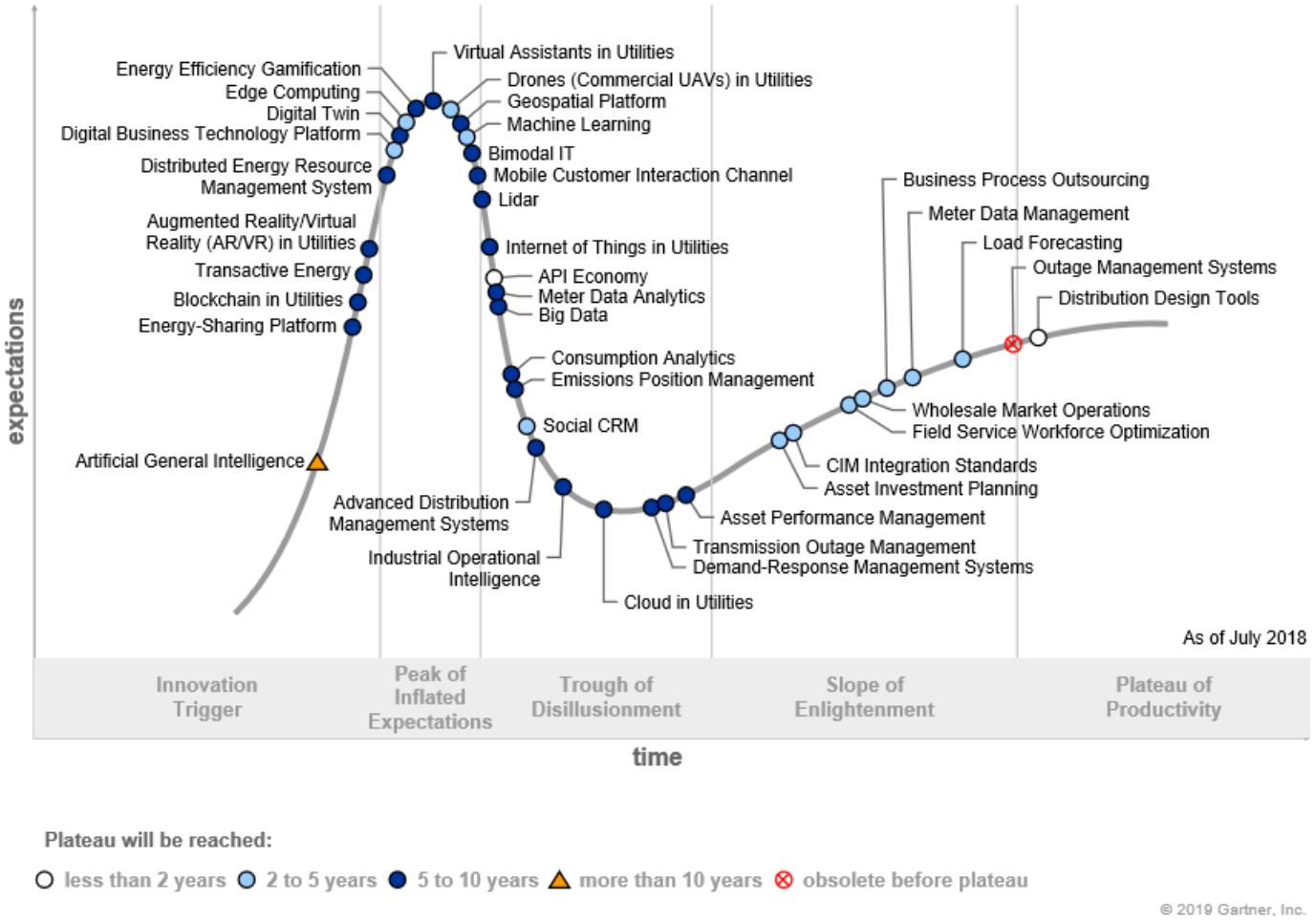
| ID | Initiative | NG Proposed | Gartner "Lower" | Gartner "Higher" | Variation | Gartner Comments |
|---|---|---|---|---|---|---|
| 460 | Restoration | 23.00 | 23.00 | 23.00 | | Gartner assumes this is the real operational tool to manage a future restoration market (~£5m) and a tool to manage restoration procedures (messaging with participating BMEs) (~£5M) ➔ £5m-£10m. This range excludes possible communications (10-20 parties involved) as well as an estimation of the cost of the analysts to prepare (18) and validate (2-3) case studies |
| 480 | Ancillary services dispatch | 5.00 | 2.00 | 4.50 | 11% | Based on a range of integration projects using observed cost per function point. Given that for NG this is a CNI project £5m is perhaps not unreasonable |
| 490 | Support CATO tender process | 0.50 | 0.29 | 0.52 | | The Gartner validation is based on contract management projects. Given that strong audit trail, confidentiality and encryption requirements will be needed due to the strictly confidential nature of the data it seems reasonable that NG are at the high end of the range |
| 500 | Zero carbon operability | 21.90 | 21.90 | 21.90 | | This is a new type of system complementing existing primary and secondary frequency response services typically found in power networks. This covers the roll-out of the completed R&D project (MCS) and a significant portion will be on "communication". One pager doesn't have the necessary information on the specific building blocks and also contains information that a high proportion of the project spend will be on the provision of a high speed/ low latency communication network (infrastructure) |
| 510 | Restoration decision support | 7.00 | 2.00 | 5.00 | 40% | Gartner assumes optimisation will not be needed real-time ~The Gartner range is based on similar tools - Black start service management with DSS and excluding settlement. If NG require high levels of customisation the estimate of £7m may not be unreasonable |

# 2. Appendix

# Gartner “Point of View”

# Gartner Point of View: Hype Cycle for Utility Industry IT

**National Grid's anticipated investment areas are well aligned to wider industry trends**




- The **Hype Cycle** is a graphical depiction of a common pattern that arises with each new technology or other innovation.
- The **Utility Industry** hype cycle considers those technologies that are a critical delivering reliable, affordable and ubiquitous services. Note that not all technologies are relevant to all types of utilities.
- Many technologies that are now reaching maturity, such as **Meter Data Management** and **Field service Workforce Optimisation** will soon disappear from the hype cycle.
- Technologies identified as having potential at **National Grid**, such **Asset Performance Management, Big Data**, **Digital Twins, Internet of Things in Utilities**, **AI/Machine Learning** and **Virtual Assistants** are anticipated to reach maturity during RIIO T2.
- Gartner's has observed that UK **GDN** and **DNO** organisations are planning investments in the same areas as **National Grid**.
- Further detail on each investment area is provided in the **appendix**.

# Gartner Point of View: 2019 CIO Agenda for the Utilities

**National Grid is considering investing in similar areas to its peers**

### Game-Changing Technologies

Percentage of Respondents

| | Utilities (n = 99) | | Top Performers (n = 230) | | Typical Performers (n = 2,329) | | Trailing Performers (n = 276) | |
|---|---|---|---|---|---|---|---|---|
| 1 | Data analytics (including predictive analytics) | 33% | Artificial intelligence/ machine learning | 40% | Artificial intelligence/ machine learning | 25% | Artificial intelligence/ machine learning | 24% |
| 2 | Artificial intelligence/ machine learning | 26% | Data analytics (including predictive analytics) | 23% | Data analytics (including predictive analytics) | 25% | Data analytics (including predictive analytics) | 21% |
| 3 | Internet of Things | 17% | Cloud (including XaaS) | 12% | Cloud (including XaaS) | 10% | Cloud (including XaaS) | 14% |
| 4 | Cloud (including XaaS) | 10% | Digital transformation | 10% | Internet of Things | 10% | Internet of Things | 11% |
| 5 | Automation | 8% | Mobile (including 5G) | 7% | Digital transformation | 9% | Digital transformation | 7% |
| 6 | Mobile (including 5G) | 5% | RPA | 6% | Mobile (including 5G) | 6% | Industry-specific | 5% |
| 7 | Business intelligence | 4% | Internet of Things | 6% | Automation | 5% | Business intelligence | 5% |
| 8 | Industry-specific | 3% | Blockchain | 5% | Blockchain | 4% | Automation | 5% |
| 9 | RPA | 3% | Automation | 3% | Industry-specific | 4% | Blockchain | 5% |
| 10 | Information technology | 2% | Information technology | 3% | Business intelligence | 3% | Mobile (including 5G) | 5% |

Base: All answering, excluding "prefer not to answer"; n varies by segment
Showing the 10 most common answers per segment, coded open-text responses, multiple responses allowed
Q: Which technology area do you expect will be a game changer for your organization?
ID: 368223



- Gartner undertake an annual survey of CIO's across many industries to understand their priorities for the coming year and beyond. A number of questions are asked, but in this specific instance CIO's were asked an open-text, unprompted answer about which technologies they see as having the potential to transform utilities.
- The technology area receiving the highest attention from utility respondents (33%) is **data analytics** (including predictive analytics). This is in line with the utility priority of optimizing asset performance and utilisation and minimising operations and maintenance costs. From weather monitoring to network operations, analytics and predictive analytics are seen to be major levers today and going forward.
- This theme continues as we move to the second-ranked technology area — **artificial intelligence** and **machine learning** (26%). These technologies in utility asset operations and maintenance are viewed as a means of driving further value from assets, using machine learning to provide faster responses to changes in circumstances and, ultimately, squeezing more production or longer life from assets. We are also seeing increased AI adoption in the customer domain, although in its rudimentary form, such as RPA.
- Again, based on the asset-intensive nature of utilities, and the need for remotely monitored operational integrity of delivery and generation assets, **IoT** receives the third-ranked slot (17%). The instrumentation and connectivity of grid-based generation and network assets, as well as assets at consumer premises (from smart meters to home energy management and automation), generate a lot of interest from utilities.

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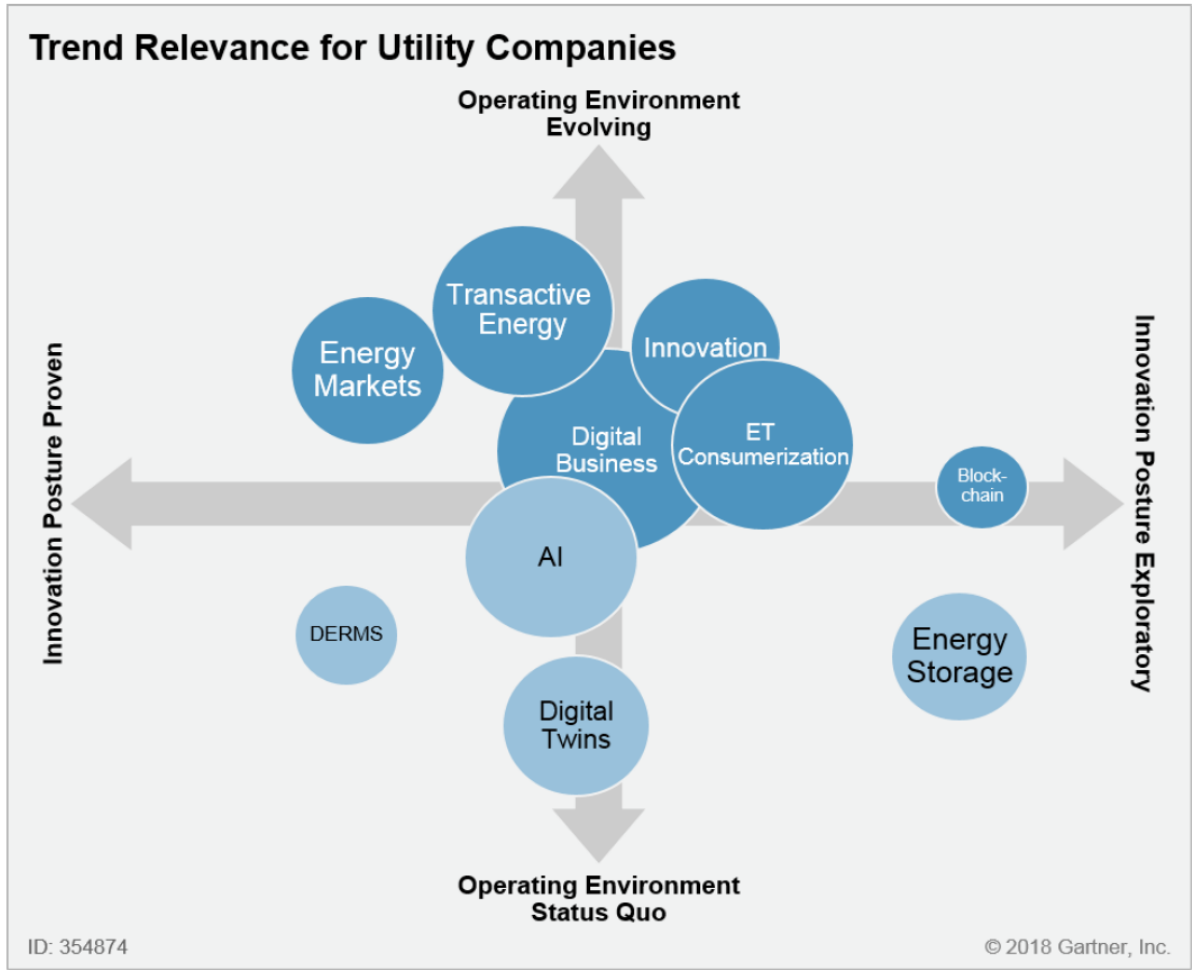
# Gartner Point of View: Top 10 Trends Driving Utility Companies

**Again, National Grid is considering investment in similar areas to its peers**




- The chart (left) depicts the relevance of a particular trend for utility companies, based on the environment in which they operate as well as their innovation posture.
- It is focussed on the *"Decarbonized, Distributed, Digital and Democratized Future"*.
- The impact of the trend is represented by the size of the circle, while the colour indicates the trend's primary contribution to "performing" goals (**light blue**) or "transforming" goals (**dark blue**).
- **AI** and **Digital Twins** (effectively an application of advanced analytics and other complementary technologies) feature prominently.
- Again, note that this covers all utility types.

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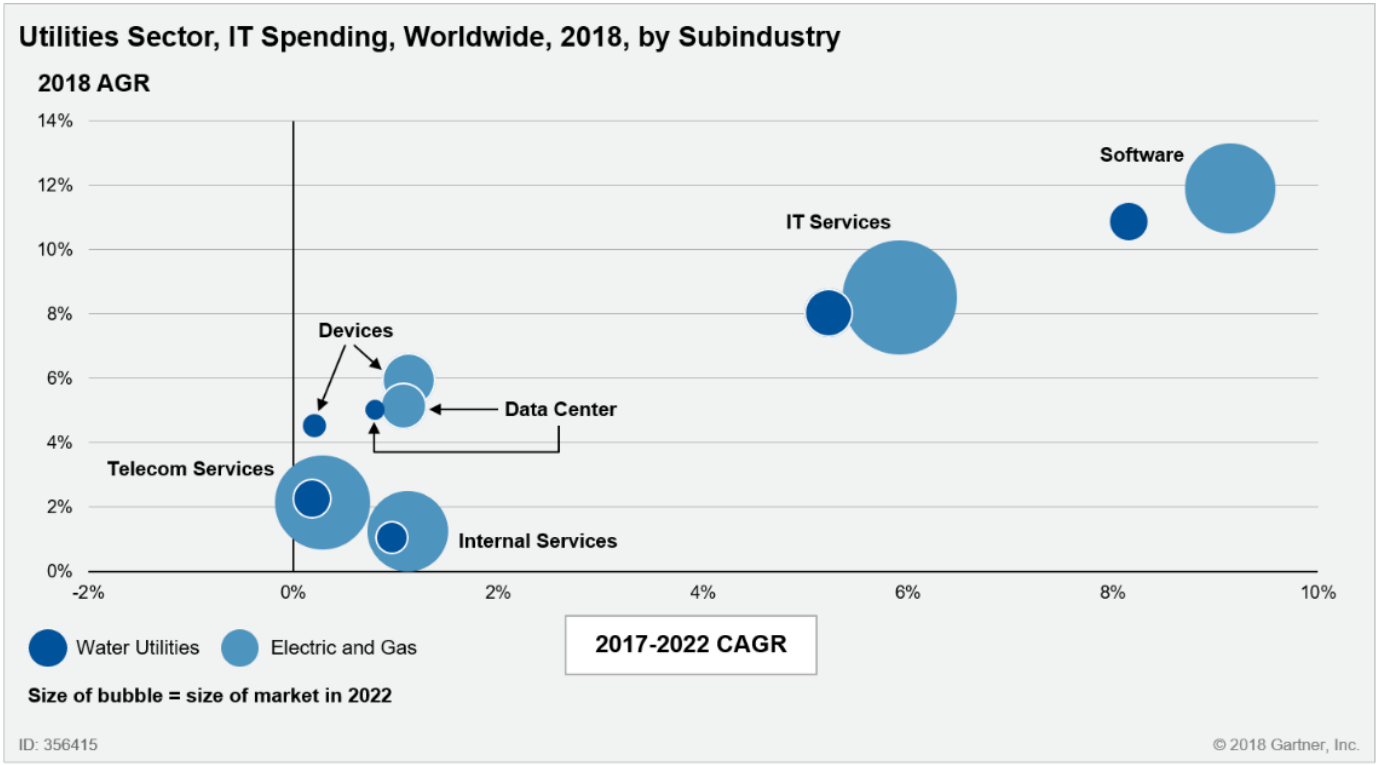
# Gartner Point of View: Utilities IT Spending, 2018

**Worldwide IT spending was $167.9 billion in 2018, growing at a 2.5% constant currency rate. The utilities sector faces many challenges, including asset intensity, growing demand for renewable energy and the ongoing search for new retail business models.**




- By 2022, 75% of global electricity retailers' IT projects will have a direct impact on customer experience (CX).
- By 2021, 33% of large and midsize organizations will have adopted some form of data preparation of self-service analytics, up from 10% in 2016.
- By 2020, organizations that offer users access to a curated catalogue of internal and external data will realize twice the business value from analytics investments than those that do not.
- By 2022, only 24% of the organizations in the utilities industry will possess sufficient digital dexterity to achieve success with products targeting new ways of work.
- Through 2022, a maximum of 7% of global utilities with pilot programs today will achieve any radical transformation with the use of blockchain technologies.
- By 2022, 25% of utilities globally will use artificial intelligence (AI)-augmented digital customer service agents to interact with customers' virtual personal assistants (VPAs) and home IoT.
- Through 2020, industrial companies that have implemented energy management system (EMS) will gain cost savings on average of 12.2% over the 3% savings from those that have not implemented EMS.
- Increased regulations around energy-efficiency and renewable sources will increase investment in energy-efficient technologies by at least by 15% through 2022.

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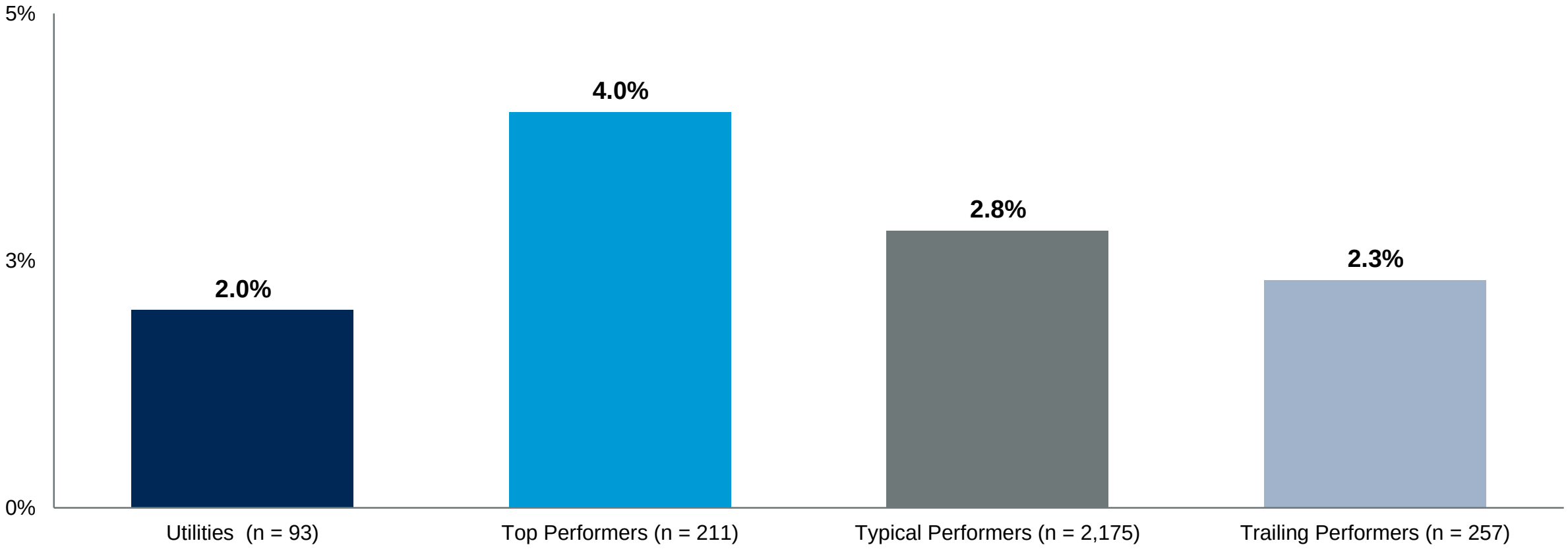
# Gartner CIO Survey 2019: Utilities IT Budgets

**Utility IT Budgets Are Expected to Grow, Although Trailing Others**

## Expected change in enterprise IT budgets

Showing averages




Q. By what percentage do you expect your organization's IT budget to increase or decrease from 2018 to 2019?
Base: All answering, excluding “Don’t know.” n varies by segment.

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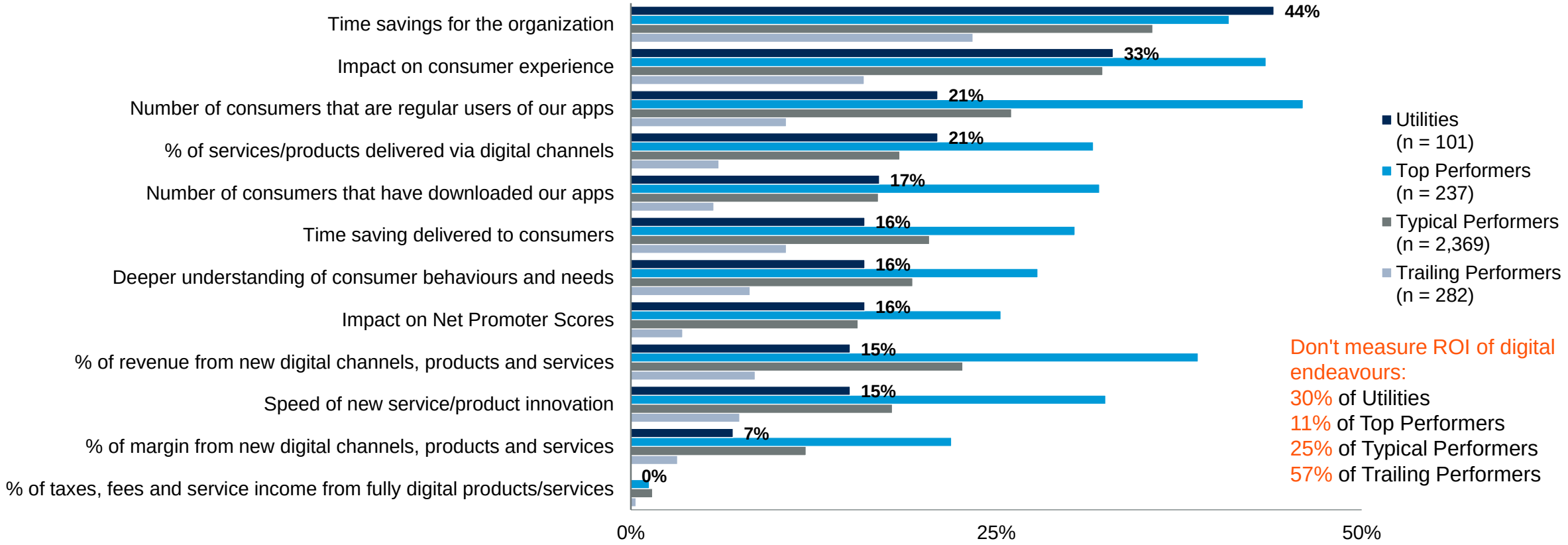
# Gartner CIO Survey 2019: Digital Investments

**Top Performers Measure the ROI of Digital Investments**

## Metrics to Rate the ROI of Digital Investments

Percentage of respondents using




Q. What metrics or key performance indicators (KPIs) does your organization use to measure the ROI of its digital investments?
Multiple responses allowed. Base: All answering; n varies by segment.

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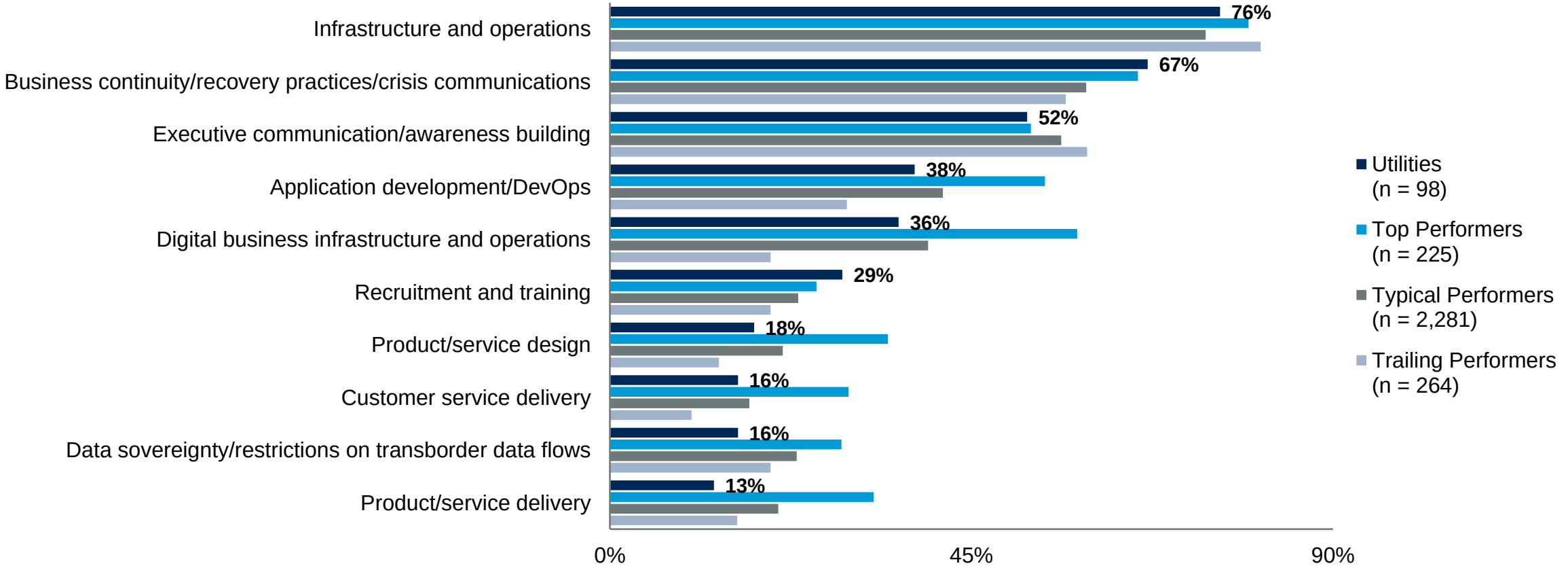
# Gartner CIO Survey 2019: Cyber Security

**Cyber-Risk Mitigation Activities: Top Performers Do More**

## Areas for Increasing Cyber-Risk Mitigation Efforts

Percentage of Respondents




Q. In which areas are cyber-risk mitigation efforts increasing in your organization? Showing the top 10 most common responses among the top performers

Base: All answering; n varies by segment. Multiple responses allowed.

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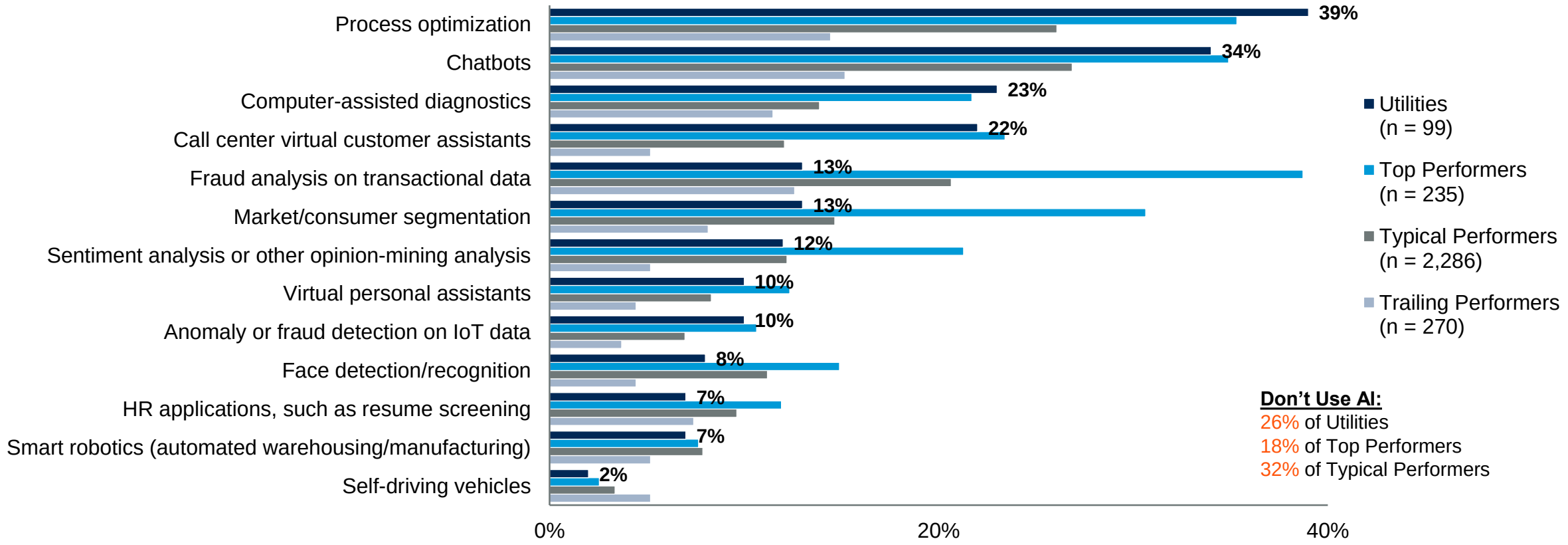
# Gartner CIO Survey 2019: Artificial Intelligence

**Identify Use Cases for Artificial Intelligence**

## Applications of AI

Percentage of Respondents




Q. Does your organization use any of these artificial intelligence (AI)-based applications? Multiple responses allowed. Base: All answering, excluding "Not sure." n varies by segment.

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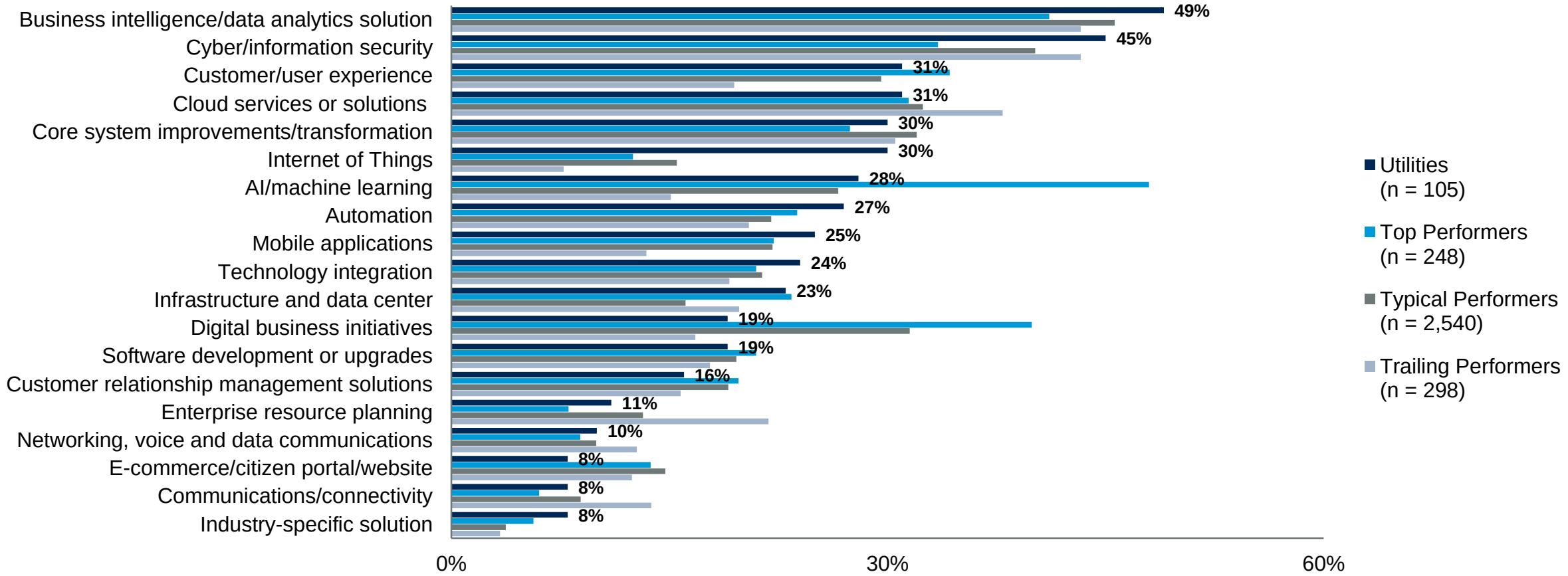
# Gartner CIO Survey 2019: Technology Investment Trends

**Rebalance Your Technology Portfolio**

## Where Organizations Are Increasing Spend

Percentage of Respondents




Q. What are the technology areas where your organization will be spending the largest amount of new or additional funding in 2019?
Base: All answering, excluding “Don’t know.” Multiple responses allowed. n varies by segment.



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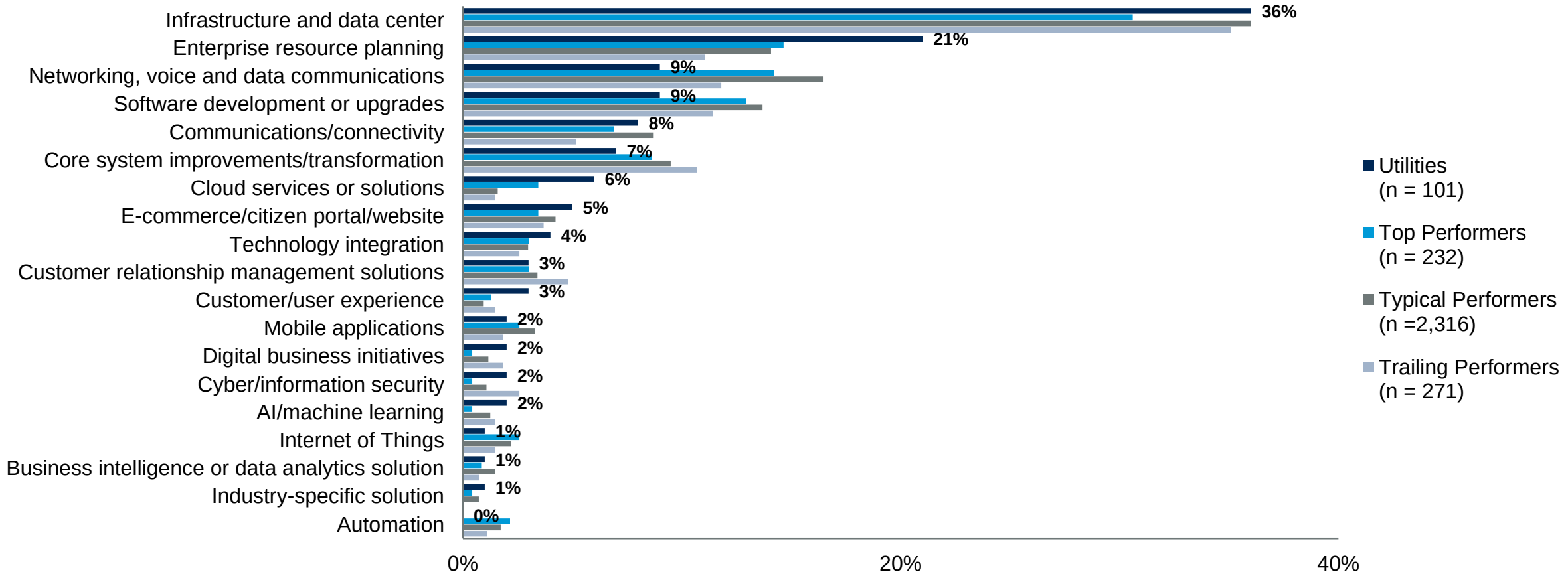
# Gartner CIO Survey 2019: Technology Investment Trends

**Rebalance Your Technology Portfolio**

## Where Organizations Are Decreasing Spend

Percentage of Respondents




Q. What are the technology areas where your organization will be reducing funding by the highest amount in 2019 compared with 2018?
Base: All answering, excluding “Don’t know.” Multiple responses allowed. n varies by segment.



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# Gartner Cited Research

# Top 10 IT Cost Optimization Techniques

**When operating costs must be reduced, CIOs evaluate spending and cost drivers. C-suite executives are most concerned about costs in their own budgets, so leverage these 10 techniques to identify cost optimization opportunities across multiple organizational budgets**

## Top Cost Optimization Techniques in IT

1. Implement shared services.
2. Adopt a cloud-first policy where appropriate.
3. Consolidate enterprise data centers.
4. Rationalize and standardize enterprise applications.
5. Improve IT financial transparency practices.
6. Focus on IT demand-side spending for greater business cost optimization.
7. Implement robotic process automation.
8. Evaluate IT asset management practices.
9. Evaluate digital business transformation ideas.
10. Optimize the workforce.

ID: 355598



## Determine Cost Optimization Approach


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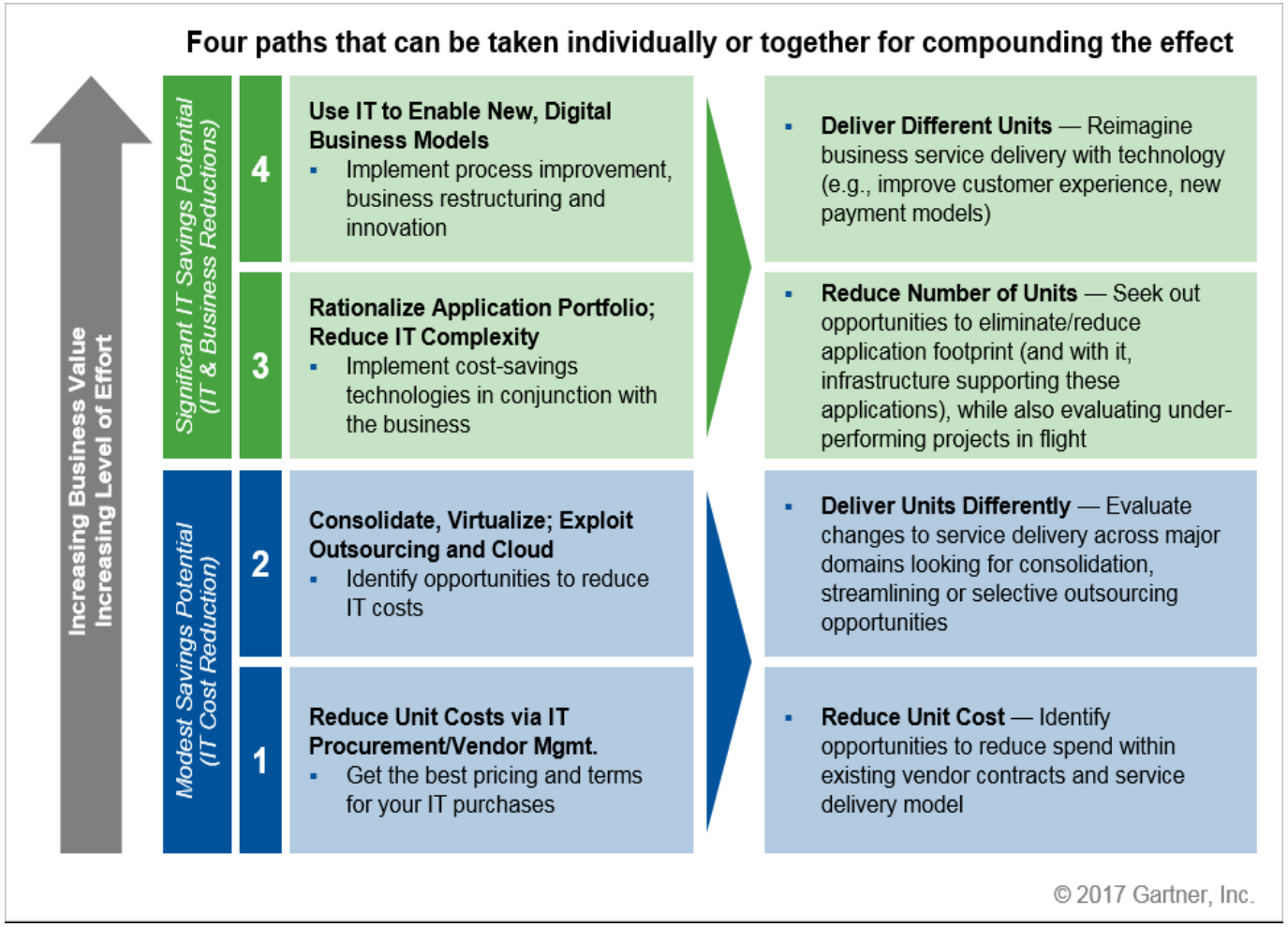
# Four Levels of Cost Optimization

**IT leaders should use Gartner's Four Levels of Cost Optimization framework as a planning and communication structure to deliver an intelligent balance of strategic and tactical IT cost control**




- Gartner has defined four levels of cost optimization, as highlighted below:

**Enable Innovation and Business Restructuring**
*Implement process improvement, business restructuring and innovation*

**Joint Business and IT Cost Savings**
*Implement cost-saving technologies in conjunction with the business*

**Cost Savings Within IT**
*Identify opportunities to reduce IT costs*

**IT Procurement**
*Get the best pricing and terms for your IT purchases*

- We recommend that organizations map their cost optimization efforts to the framework to help determine if their overall initiative is out of balance (all cuts coming from cost savings in IT, for example) or whether the organization has mixed IT costs savings with an appropriate amount of optimization techniques (such as innovation and business restructuring) that prepare the organization for a return to growth.

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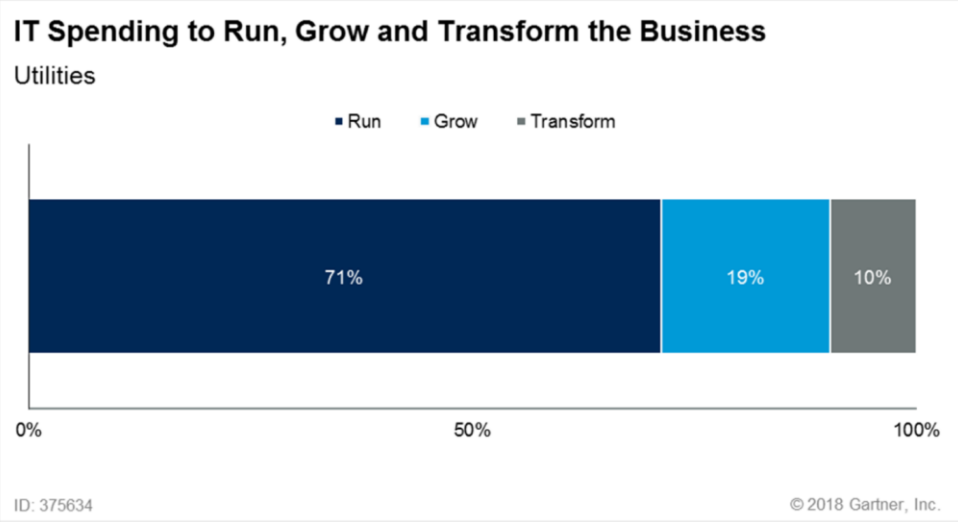
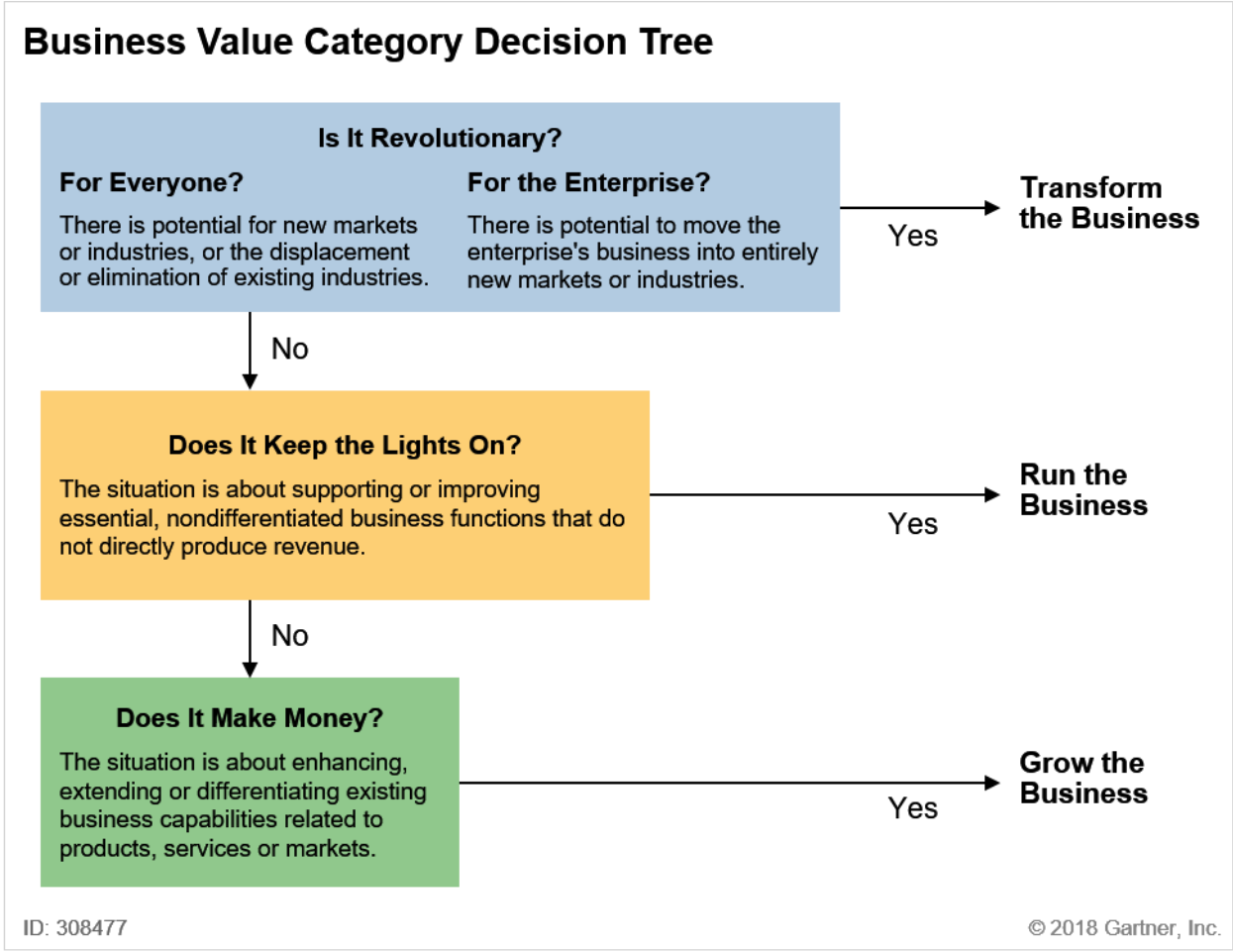
# Business Value Category Decision Tree

**The run, grow and transform the business framework is a starting point for the overall process of measuring, forecasting and communicating IT value.**

- Gartner believes that the initial language and metrics used for business value are critical success factors in the organization's ability to make good IT investment decisions.
- For organizations that are looking for best practice, consider linking individual IT services to individual business process performances in a causal chain.







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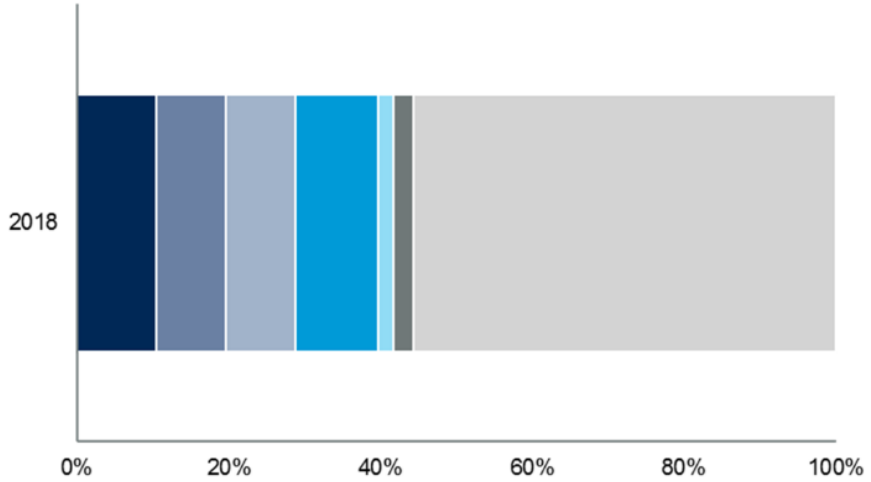
# IT Key Metrics 2019: Application Development

**Distribution of work across the applications project lifecycle can be an effective measure to understand where time and effort are typically spent and can help identify opportunities for performance improvement**

## Application Development FTEs



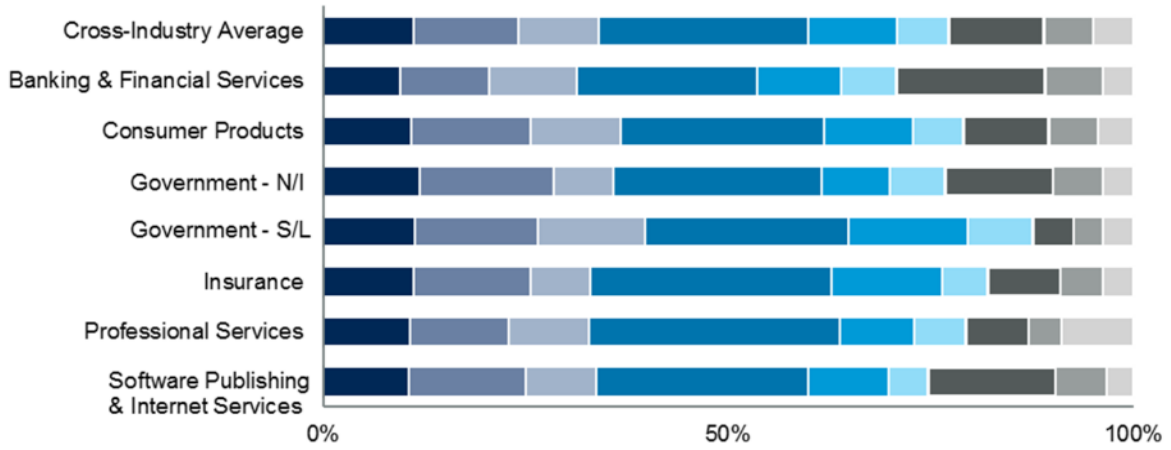

| | 2018 |
|---|---|
| Business Analysis/Arch. | 10% |
| Quality Assurance/Testing | 9% |
| Project/Program Mgt. | 9% |
| Services Mgt/Administration | 11% |
| IT Process Management | 2% |
| Logical Database Analysts | 3% |
| Development | 56% |

ID: 375665



## Application Development Lifecycle

By Industry




| | Software | Professional Services | Insurance | Govt - S/L | Govt - N/I | Consumer Products | Banking & Financial Services | Cross-Industry Average |
|---|---|---|---|---|---|---|---|---|
| Project Management | 11% | 11% | 11% | 11% | 12% | 11% | 10% | 11% |
| Requirements Analysis & Mgmt | 14% | 12% | 14% | 15% | 17% | 15% | 11% | 13% |
| Design | 9% | 10% | 7% | 13% | 7% | 11% | 11% | 10% |
| Development Time & Unit Testing | 26% | 31% | 30% | 25% | 26% | 25% | 22% | 26% |
| System Testing | 10% | 9% | 14% | 15% | 8% | 11% | 10% | 11% |
| Defect Removal | 5% | 6% | 6% | 8% | 7% | 6% | 7% | 6% |
| Implementation & Deployment | 16% | 8% | 9% | 5% | 13% | 11% | 18% | 12% |
| Quality Management | 6% | 4% | 5% | 4% | 6% | 6% | 7% | 6% |
| Training & Other | 3% | 9% | 4% | 4% | 4% | 4% | 4% | 5% |

ID: 375665



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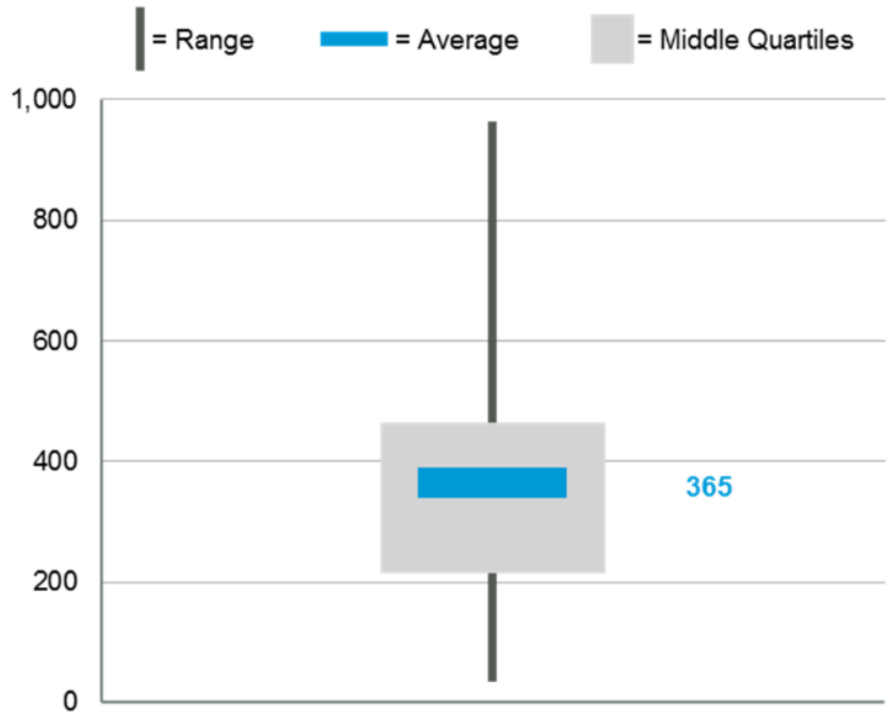
# IT Key Metrics 2019: Function Points

**The function point (function point) represents a unit of measure of the automated functionality delivered to the end user by an application. function points developed per application development full-time equivalent (FTE) is a common measure of application development productivity.**

## Function Points Developed per Development FTE

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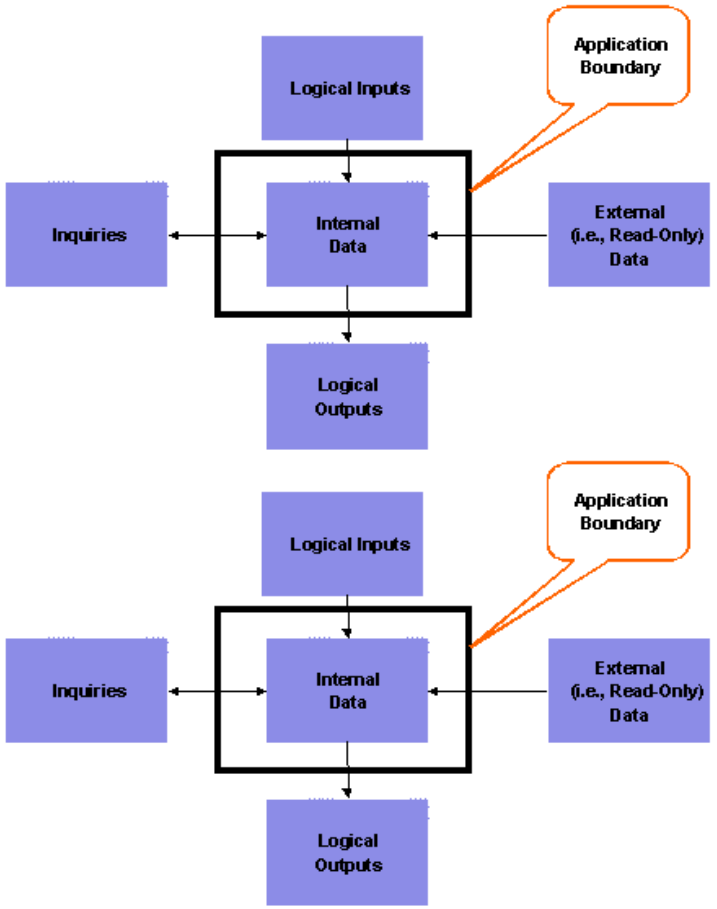





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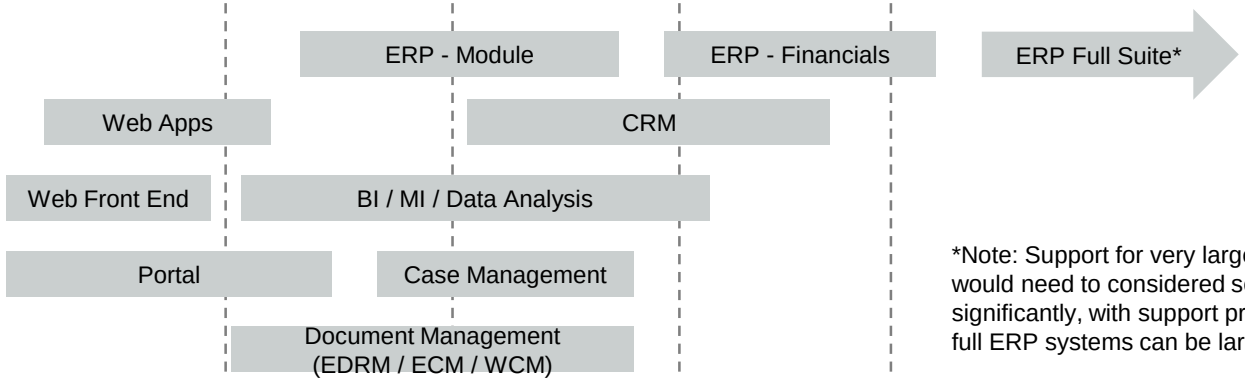
# Application Sizing Guidelines

**Where requirements or specifications are lacking, Gartner used the model to categorize and size applications included in the investment plan.**

| Application Characteristics | Unit | Small | Medium | Large | X.Large | V.Large |
|---|---|---|---|---|---|---|
| Tables/Structures Maintained & Used by Application | Tables | Less than 50 | 51 to 100 | 100 - 400 | 401 - 1000 | Specific sizing |
| Screens to Maintain & Browse Business Data | Screens | Less than 50 | 51 to 100 | 100 - 400 | 401 - 800 | Specific sizing |
| Background Processes | Background processes or batch jobs | Less than 50 | 51 to 100 | 101 - 250 | 251 - 500 | Specific sizing |
| Reports | Reports | Less than 50 | 51 to 150 | 151 - 300 | 301 - 500 | Specific sizing |
| Interfaces From & To Other Applications | Interfaces | Less than 10 | 11 to 50 | 51 - 100 | 101 - 200 | Specific sizing |
| Size used in Gartner Assessment | Function Point | 500 | 1,500 | 5000 | 12,000 | Specific sizing |

## Example Applications Sizing

- The functional size of different application types will clearly vary depending on specific functionality, and it is difficult to define that one type of application will tend to be larger/smaller than another. However the diagram to the right represents example ranges observed by Gartner.
- In-house or bespoke developed applications are most commonly in the Small to Medium category and when compared with COTS packages are often smaller.
- Gartner propose that where EA applications cannot be simply categorised by a consensus between parties the model above can be used to guide the applications sizing




*Note: Support for very large applications such as ERP suites would need to considered separately as the sizing can vary significantly, with support pricing linked to licensing costs. (e.g. full ERP systems can be larger than 100,000function points)

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# Utility Industry Hype Cycle Detail

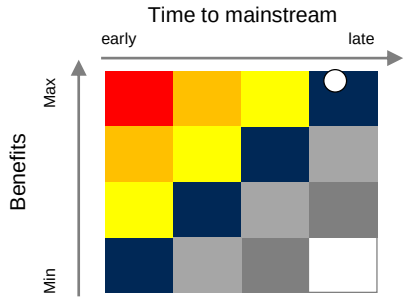
# Utility Industry Hype Cycle

## Artificial General Intelligence

### Definition

Artificial general intelligence (AGI) — also known as "strong AI" and "general-purpose machine intelligence" — would handle a very broad range of use cases, if it existed. It does not, though it is a popular subject of science fiction. Current AI technologies do not deliver AGI. Despite appearing to have human-like powers of learning, reasoning and adapting, they lack common-sense, intelligence, and extensive means of self-maintenance and reproduction. Special-purpose AI — "weak AI" — does exist, but only for specific, narrow use cases.

### Priority Matrix




### Justification

Tangible progress on AI has been limited to weak AI. AGI's position and adoption speed on this Hype Cycle therefore remain unchanged. (We changed this entry's name from "general-purpose machine intelligence" in 2017 to reflect the popularity of the term "AGI.")

Today's AI technology cannot be proven to possess the equivalent of human intelligence (the lack of agreement about a test to prove such intelligence is itself a problem). It may, at some point, be possible to build a machine that approximates human cognitive capabilities, but we are likely decades away from completing the necessary research and engineering.

The subject of AGI often arises in discussions of "cognitive computing" — a term that means different things to different people. For some it denotes a set of AI capabilities, for others a specialized type of hardware (as in neuromorphic or other highly parallel, short propagation path processors). It can also describe the use of information and communication technology to enhance human cognition, which is how Gartner uses the term.

### Impact

AGI is unlikely to emerge in the next 10 years, although research will continue. When it does finally appear, it will probably be the result of a combination of many special-purpose AI technologies. Its benefits are likely to be enormous. But some of the economic, social and political implications will be disruptive — and probably not all positive.

There are currently no vendors of systems that exhibit AGI, but many companies are engaged in basic research. Examples are DeepMind (owned by Google), OpenAI and Vicarious.

### Vendors

N/A

### Market Penetration

Less than 1% of target audience

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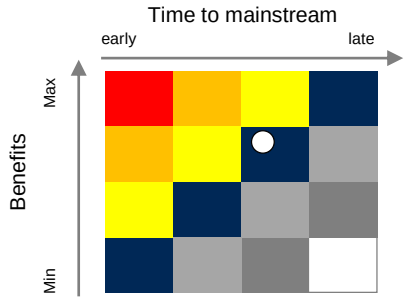
# Utility Industry Hype Cycle

## Energy Sharing Platform

### Definition

The energy-sharing platform leverages sharing economy (or network economy/economy of connections) principles to enable energy exchanges between individual prosumers with extra production capacity and consumers interested in using this capacity. It is a dual platform architected to effectively integrate prosumers into energy markets in a controlled manner that also provides additional revenue opportunities for utilities.

### Priority Matrix




### Justification

Energy-sharing platform is an example of new revenue opportunities enabled by digital transformation and democratization of the energy sector. It uses platform as the most common digital business model. By leveraging economies of connection and digital disruption at the edge of the grid, it creates the new revenue opportunities for utilities. The emergence of prosumers — the most significant disruption in the utility sector, driven by energy technology consumerization and innovation at the edge of the grid — is creating challenges to the existing utility business model. One possible way for utilities to counter the disruptive impact of prosumerization is to become a provider of the energy-sharing platform. Such a platform would enable integration of prosumer-owned distributed energy resources into energy markets by exposing available DER directly to consumers. By managing an information exchange platform, utilities will enable value exchange (by leveraging data, analytics, algorithms) among parties, and be able to capture a share of the created value. This will allow utilities to supplement existing revenue, and compensate for loss of revenue caused by customer exodus, by becoming a company that provides an energy-sharing platform.

### Impact

An energy-sharing economy platform will impact the commercial side of utilities via implications on the revenue management cycle (meter-to-cash) and consumption analytics. Digital distribution platform side will impact network operation requiring a combination of traditional network control function and economic-based control mechanism such as congestion management via distribution marginal prices.

### Vendors

LichtBlick, Open Utility, Power Ledger, Powerpeers

### Market Penetration

Less than 1% of target audience



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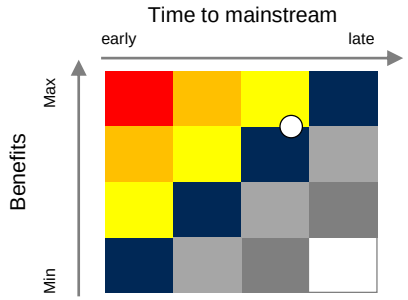
# Utility Industry Hype Cycle

## Blockchain in Utilities

### Definition

A blockchain is an expanding list of cryptographically signed, irrevocable transactional records shared by all participants in a network. Each record contains a time stamp and reference links to previous transactions. With this information, anyone with access rights can trace back a transactional event, at any point in its history, belonging to any participant. A blockchain is one architectural design of the broader concept of distributed ledgers.

### Priority Matrix




### Justification

Blockchain continues on its journey of hype, inflated expectations, misinformation, misunderstanding and questionable immediate value. There are wrong assumptions, created by media and vendors, that blockchain is already being actively deployed across enterprises, and that a larger transformation is underway.

Blockchain's potential is in its ability to disrupt the existing business environment and enable democratization of the business processes that are traditionally managed by a central authority (such as a government department, a bank or an electric utility) This is because blockchain is an effective mechanism for achieving distributed consensus in the face of an unsafe, unreliable networked environment with a dynamic collection of untrusted participants.

### Impact

Blockchain technology is gaining traction in utility sector (see "Top 10 Trends in 2018 Driving the Utility Industry Toward a Decarbonized, Distributed, Digital and Democratized Future" G00354874), because it has the promise to transform the transaction flows and offer a new way of managing and operating distributed assets and operations, some of it outside of utility direct ownership or control. In the energy utility sector, the primary impact will be enabling democratization of energy provisioning, such as managing micro energy transactions between prosumer-owned DER and consumers.

### Vendors

Bankymoon, Electron, Ethereum, Global SolarChange, Grid+, IBM, Leap, LO3 Energy, Power Ledger

### Market Penetration

Less than 1% of target audience



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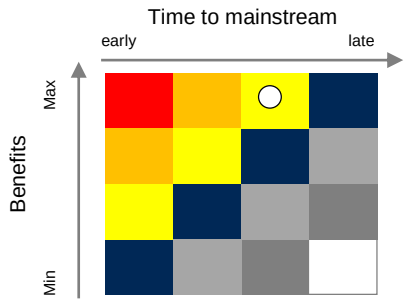
# Utility Industry Hype Cycle

## Transactive Energy

### Definition

Transactive energy (TE) refers to techniques for managing the generation, consumption or flow of electric power within an electric power system through the use of economic or market-based constructs while considering grid reliability constraints. TE is an economic-value-based network control concept, not a system.

### Priority Matrix




### Justification

Traditional economic and business models for electric utilities are being challenged by the growth and diversity of distributed energy resources. Transactive energy is being proposed by industry leaders as a path forward. The TE framework is intended to develop new economic constructs that accurately capture the value of energy transactions at the distribution network level. These economic valuation techniques then make it possible to optimize grid solutions across generation, transmission and distribution.

### Impact

CIOs at utilities that are affected by aggressive renewable portfolio standards or by rapid adoption of consumer renewable energy or storage technologies will want to start early on understanding transactive energy. Operations executives tasked with minimizing transmission congestion, managing peak loads, or integrating responsive loads will want to work with their system vendors to understand how TE will affect their product roadmaps.

### Vendors

Enphase, IBM, Integral Analytics, Intel, Itron, Nexant, OATI, Opus One Solutions, Oracle

### Market Penetration

Less than 1% of target audience




nationalgrid Gartner

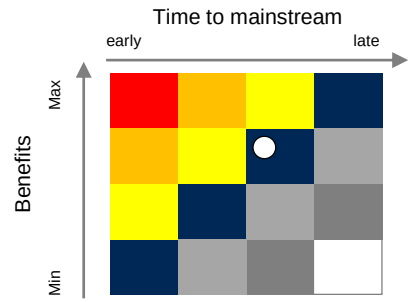
# Utility Industry Hype Cycle

## Augmented Reality (AR) and Virtual Reality (VR) in Utilities

### Definition

Virtual reality and augmented reality are two different, yet related, technologies. Virtual reality technologies create computer-generated environments to immerse users in a virtual environment. Augmented reality technologies overlay digital information on the physical world in order to enhance it and guide action. AR and VR are experienced through a display device that can provide either a video feed or a direct view of the real world. Audio, text, gesture recognition or handheld controllers may be incorporated.

### Priority Matrix




### Justification

VR and AR markets are fragmented and many industry-specific applications, while expanding, are still exploratory. These markets are currently struggling with mismatched expectations (vendors promising solutions beyond current capabilities) and poor implementations (for example, solutions delivered without immersive development knowledge, workflow integration, or mapped to business value or need). B2C implementations are still struggling to show consumers value. Better and more transparent hardware, coupled with more compelling use cases, are needed before further progress can be made.

### Impact

Transmission and distribution planning, engineering design, network operations, asset maintenance, field service, property management, EAM and generation plant licensing will be affected by utility-augmented reality and virtual reality technologies. AR/VR can help in providing ways for the utility to be more productive and work more efficiently through crew location capabilities and enable safer work environments with visual display and training capabilities.

### Vendors

DAQRI, Google, Kopin, Microsoft

### Market Penetration

1% to 5% of target audience




nationalgrid Gartner

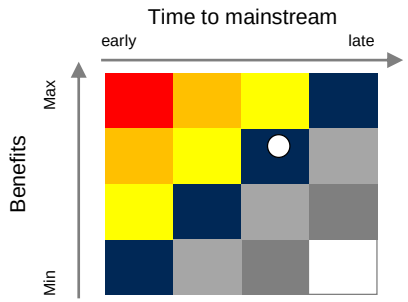
# Utility Industry Hype Cycle

## Distributed Energy Resource Management System

### Definition

A distributed energy resource management system (DERMS) is used to manage distributed energy resources (DERs) that are connected to the electric distribution grid, making these resources more accessible and beneficial.

### Priority Matrix




### Justification

Continuing intense focus on integrating distributed energy resources (DER) into the distribution gird is driving DERMS development and propelling it toward the Peak of Inflated Expectation.

DERs pose unique control challenges because of varying ownership (utilities, prosumers, aggregators, large commercial and industrial [LC&I] customers), high volume, geographical distribution, fast-changing performance characteristics and the resulting high level of operational uncertainty. Some solutions rely more on iterative optimization and forecasting algorithms, while others depend on closed-loop control. An accurate distribution grid network model is required, and complete solutions include software, hardware and communications interfaces. Numerous industry organisations are working on equipment standards and communications protocol standards to support these functions. Project teams should carefully specify the use cases, functional capabilities and performance requirements of these systems because of the diversity and immaturity of product offerings.

### Impact

Business areas most affected by DERMS implementations will be distribution network operations and distribution network engineering. However, DERMS offers benefits to transmission network operations and commodity management. DERMS will also be relevant to DER aggregators who plan to offer various services into distribution-level energy service markets (as they develop).

Successful deployment in DERMS will also likely require changes across utility operations, from customer service to network design and control centre operations. The DERMS business process landscape inside utilities, including automated, will need to expand and change correspondingly.

### Vendors

ABB, Enbala, GE, Greensmith, Siemens, Smarter Grid Solutions, Spirae

### Market Penetration

Less than 1% of target audience




nationalgrid Gartner

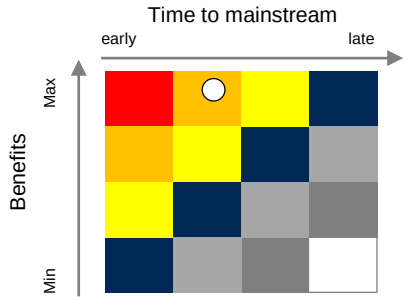
# Utility Industry Hype Cycle

## Digital Business Technology Platform

### Definition

A digital business technology platform is the combination of technologies that enables an organisation to participate in digital business ecosystems. It integrates existing platforms for IT, customer engagement, data and analytics, ecosystem partners and the Internet of Things to create new capabilities to detect business events, decide what to do, and implement a business response. Platforms share assets such as data, algorithms and transactions (both monetary and nonmonetary) with business ecosystems to match, create and exchange services.

### Priority Matrix




### Justification

Companies use a variety of new integration and cloud technologies to implement digital businesses technology platforms today. While digital native organisations are adept at these technologies, traditional companies often struggle with new architectural approaches, such as microservices architecture, event-driven architecture, and programmable infrastructure that are required for large-scale implementations and the rapid change in these technology markets.

### Impact

DBTPs enables an enterprise to become a digital business. Without it, it will be much harder for an enterprise to gain the business benefits of digital business. They empower people, businesses and things to give, take or multiply value creation for the enterprise. Digital platforms will make it easier for new market entrants, start-ups, competitors and, eventually, smart machines to create and pursue new business opportunities. Traditional businesses will have to build a digital business technology platform to compete and/or participate in these new markets.

### Vendors

N/A

### Market Penetration

5% to 20% of target audience



nationalgrid Gartner

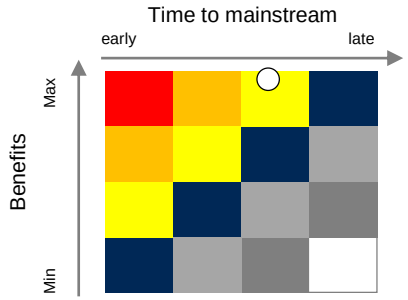
# Utility Industry Hype Cycle

## Digital Twin

### Definition

A digital twin is a virtual representation of a real object. Digital twins are designed to optimize the operation of assets or business decisions about them, including improved maintenance, upgrades, repairs and operation of the actual object. Digital twins include the model, data, a one-to-one association to the object and the ability to monitor it.

### Priority Matrix




### Justification

The idea of modelling the operational behaviour of things and processes continues to gain traction.

Hundreds of millions of things will have digital twins within five years.

The digital twin profile has moved closer to the Peak of Inflated Expectations, in part due to heavy promotion by technology and service providers. Although about 5% of enterprises have started implementing digital twins, less than 1% of assets have digital twins.

For operators of assets (aircraft, buildings, power plants, windmills), digital twins are starting to gain adoption. Their primary near-term use is lowering maintenance costs and increasing asset uptime.

For product OEMs, digital twins are beginning to proliferate for connected products (cars, lights, stereos). The primary near-term use of digital twins is differentiation and to help the enterprise manage warranty costs, support channel partners and better understand customer experiences.

### Impact

Digital twins are transformational as they enable business to optimize or transform their current business models. In the next decade, digital twins will become the dominant design pattern for solutions.

For example, they enable superior asset utilization, service optimization and improved customer experience. They create new ways to operate, such as consumption of physical outcomes instead of the capital expenditure acquisition of industrial assets. And they will open up new ways to monetize data.

### Vendors

ANSYS, Cognite, Dassault Systèmes, Flutura Decision Sciences and Analytics, GE Digital, IBM, Microsoft, Particle, PTC, Siemens PLM Software

### Market Penetration

1% to 5% of target audience




nationalgrid Gartner

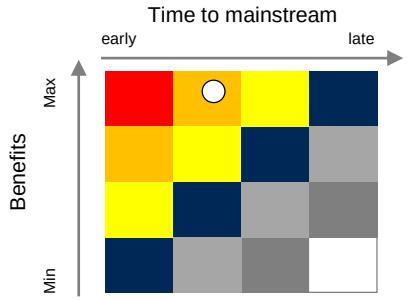
# Utility Industry Hype Cycle

## Edge Computing

### Definition

Edge computing describes a distributed computing topology where information processing is placed close to the things or people that produce and/or consume that information. Drawing from the concepts of mesh networking and distributed data centres, edge computing looks to keep traffic and processing local and off the centre of the network. The goals are to reduce latency, reduce unnecessary traffic, and establish a hub for interconnection between interested peers and for data thinning of complex media types or computational loads.

### Priority Matrix




### Justification

Most of the technology for creating the physical infrastructure of edge data centres is readily available, but widespread application of the topology and explicit application and networking architectures are not yet common outside of vertical applications such as retail and manufacturing. As IoT demand and use cases proliferate, the acceptance of edge computing as the topological design pattern (namely the “where” a “thing” is placed in an overall architecture) has dramatically increased interest in edge. Systems and networking management platforms will need to be stretched to include edge locations and edge-function-specific technologies such as data thinning, video compression and analysis.

### Impact

Edge computing solves many pressing issues such as unacceptable latency and bandwidth limitations given a massive increase in edge-located data. The edge computing topology will enable the specifics of IoT, digital business and IT solutions uniquely well in the near future.

### Vendors

Amazon, Apple, Google, Microsoft

### Market Penetration

5% to 20% of target audience



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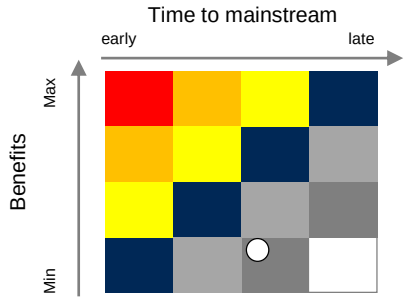
# Utility Industry Hype Cycle

## Energy Efficiency Gamification

### Definition

Energy efficiency gamification applies game mechanics to drive ongoing consumer engagement in energy conservation. Although typical strategies include contests and rewards for conserving energy, social media elements, such as communities, and indicators of status and success, including badges and leader boards, gamification is not a rewards program. Gamification is designed to encourage ongoing interaction. It can be part of data and analytics for an energy management system, or a stand-alone program or application.

### Priority Matrix




### Justification

Low consumer interest and engagement in energy management are utility industry challenges, especially for utilities tasked with achieving end-user energy efficiency improvements. Gamification applies game mechanics to motivate people and change behaviour. Utilities can use gamification to improve customer engagement in energy efficiency programmes. By 2015, the American Council for an Energy-Efficient Economy (ACEEE) had identified 22 gamified solutions deployed by utilities. The largest energy savings were achieved by winners of utility-sponsored contests (upward of 50%). However, results indicate that average savings among participants can fall in the 3% to 6% range. In 2016, the ACEEE continued to study results and found that games can reduce energy consumption by as much as 6.6%. However, it is not clear if energy savings persist after the game ends. In the EU, energy efficiency gamification has been promoted through Horizon 2020 funding. Initiatives such as the FEEdBack project are underway exploring how, via gamification apps, behaviours can be modified in three climate zones across the continent in three types of buildings. Interest in energy gamification is growing, but as yet, take-up is relatively small.

### Impact

Energy efficiency gamification can be used by demand-side management departments as a niche conservation measure that engages a subset of customers. Incorporating consumption data from meter data management systems improves programs, and integration with utility customer information systems (CIS) and/or CRM systems can help track and manage customer participation. Gamification can also be used by competitive energy retailers to support customer acquisition and retention efforts. It also has potential for improving utility employee performance in call centres.

### Vendors

Bidgely, Intelen, JouleBug, Oracle, Simple Energy

### Market Penetration

Less than 1% of target audience

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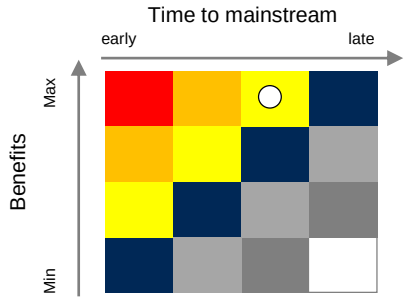
# Utility Industry Hype Cycle

## Virtual Assistants in Utilities

### Definition

Virtual assistants (VAs) help users with a set of tasks previously only done by humans. VAs use AI and machine learning to assist users and automate tasks. VAs listen and observe behaviours, build and maintain data models, and predict and recommend actions. They may act for the user, forming an event- or context-based relationship with the user over time. VAs shift responsibility for understanding processes from the user to the system by corresponding with the user and act via integration with back-end applications.

### Priority Matrix




### Justification

The space is currently dominated by conversational agents such as Apple Siri, Google Assistant, Microsoft Cortana, IPsoft Amelia, Nuance Nina, Amazon Alexa, Kore.ai and SAP CoPilot. Increasingly, image recognition, behaviour and event triggers will enhance VAs. VAs can be deployed across use cases, including virtual personal assistants, virtual customer assistants and virtual employee assistants. VA adoption grows as APIs and ecosystems mature, as the technologies improve and as the variety of implementations multiply:

Low-interactivity VA-like features embedded in existing products such as household and commercial appliances are growing, as are narrow-purpose VAs (such as connected home energy-management services).

VAs are becoming centrepieces of cross-platforms (such as Microsoft's Cortana Intelligence Suite).

General-purpose VAs (such as Siri, Google Now, Alexa and Cortana) continue to grow and evolve.

VAs can act on behalf of both consumer and business users.

### Impact

VAs have the potential to transform customer experience and workplace experience. Over time, they may become more ubiquitous, impacting the pace of work, the nature of work and human-machine job roles and interaction.

### Vendors

Apple, Go Moment, Google, IBM, Microsoft, Nuance, x.ai

### Market Penetration

1% to 5% of target audience




nationalgrid Gartner

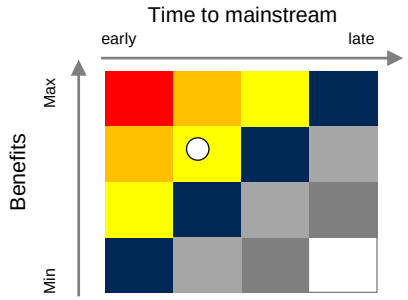
# Utility Industry Hype Cycle

## Drones (Commercial unmanned aerial vehicles) in Utilities

### Definition

Commercial unmanned aerial vehicles (UAVs) are small helicopters, fixed-wing airplanes, multirotors and hybrids, remotely controlled by human pilots on the ground or outfitted for autonomous navigation. UAVs typically incorporate global navigation satellite system (GNSS), camera, and sensors guiding them in imaging, thermal and spectral analysis. Memory caches and communications links enable UAVs to collect datasets or transmit them for storage or processing to the cloud. Collision avoidance systems are increasingly included on these systems.

### Priority Matrix




### Justification

Commercial applications of UAVs are growing as several related technology trends converge and drones are fast becoming a key Internet of Things (IoT) technology for enterprises in a growing number of verticals, such as utilities. Related trends spurring expansion include advances in camera and video imaging, 3D mapping and modelling, GPS capabilities, flash memory and gyroscopes, as well as improved mathematical algorithms. UAV-created video and imagery can present immediate value to energy and utility organisations with geographically distributed assets requiring regular inspection. The Electric Power Research Institute (EPRI) in the U.S. has concluded that UAVs can be effectively deployed to assess electric transmission and distribution (T&D) system damage following severe storms.

### Impact

Electric utility organisations can use UAVs for regular planned inspections of transmission towers and insulators, checking field conditions where tree growth intrudes on line clearances, monitoring protected species (such as salmon migration past hydroelectric dams), assessing damage to lines and poles following severe ice or wind storms, and performing aerial assessments of easement violations along transmission corridors.

Independent power producers will use UAVs for inspecting renewable systems such as solar panels, wind turbines and hydroelectric plants. Drones are also used to inspect hard-to-reach equipment at thermal-generation plants, such as boilers and cooling towers.

### Vendors

Aeryon Labs, Ascending Technologies, DJI, Hawkeye Systems, Hexagon, Pix4D, PrecisionHawk, senseFly, Skycatch, Trimble

### Market Penetration

5% to 20% of target audience

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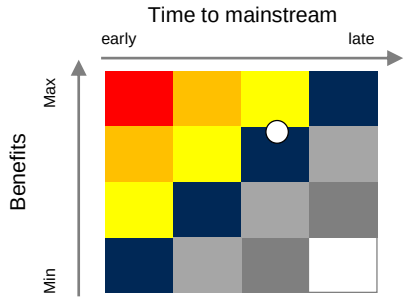
# Utility Industry Hype Cycle

## Geospatial Platform

### Definition

Geospatial platforms include platform as a service (PaaS) and data as a service offerings in the context of spatial data processing, such as web mapping, mobile geospatial apps, location services, imagery services, analytics and geoevent processing. They also include other features such as digital marketplaces with subscription-based licensing and revenue-sharing mechanisms for partner- and customer-generated apps and content.

### Priority Matrix




### Justification

Location is one of the most important pieces of information for contextualizing transactional, mobile and sensor data. Analysing operational data in the context of location can uncover spatial trends, dependencies and patterns that are otherwise undetectable. Geospatial platforms are just past the peak of the Hype Cycle as utility organisations increasingly comprehend the value of location to better understand and engage customers and citizens, optimize asset usage and improve operational efficiencies. Greater adoption, broader utilization and new technologies and services are being driven by the Internet of Things (IoT).

Geospatial platforms are gaining adoption as traditional GIS solutions mature on the Plateau of Productivity. Many traditional utility GIS applications are being refactored to leverage new architectural patterns. Core geospatial functions are expressed as web services, interfaces are expressed as RESTful application programming interfaces and HTML5-based apps consume these services. The web map has become the digital expression of geospatial content.

### Impact

Developing a geospatial platform strategy can help utility IT organisations implement a pace-layered strategy, deploying innovative applications in record time. GIS developers in IT organisations as well as "citizen developers" in business units can easily develop web and mobile applications that access geospatial services. Maps can be easily expressed as services and put to business use in a more agile delivery model, and the user experience will be more similar to the broadly available consumer mapping and geosearch experiences.

### Vendors

Esri, GE, Google, Hexagon, Pitney Bowes (MapInfo), Ubisense

### Market Penetration

5% to 20% of target audience



nationalgrid Gartner

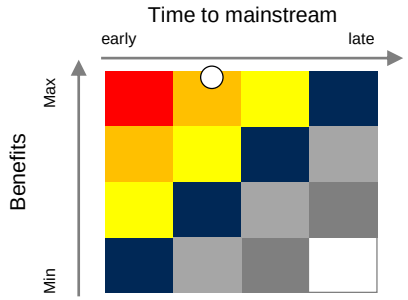
# Utility Industry Hype Cycle

## Machine Learning

### Definition

Machine learning is a technical discipline that aims to solve business problems utilizing mathematical models that can extract knowledge and pattern from data. There are three major subdisciplines that relate to the types of observation provided: supervised learning, where observations contain input/output pairs (also known as "labelled data"), unsupervised learning (where labels are omitted), and reinforcement learning (where evaluations are given of how good or bad a situation is).

### Priority Matrix




### Justification

Machine learning is still one of the hottest concepts in technology, given its extensive range of effects on business. The drivers of its continued massive growth and adoption are the growing volume of data and the complexities that conventional engineering approaches are unable to handle. An increasing number of organisations are exploring use cases for machine learning and many are already in the initial phases of pilot/POC. Tech providers are adding embedded machine learning capabilities into their software. Despite the heightened interest in the technology, most organisations are still dabbling in their approaches to machine learning. Finding relevant roles and skills needed to implement machine learning projects is a challenge for such organisations. As the volume and sources of data increase, the complexity of systems will also grow and, in such scenarios, traditional software engineering approaches would produce inferior results. In the future, advances in many industries will be impossible without machine learning.

### Impact

Machine learning drives improvements and new solutions to business problems across a vast array of business, consumer and social scenarios:

Machine learning impacts can be explicit or implicit. Explicit impacts result from machine learning initiatives. Implicit impacts result from products and solutions that you use without realizing they contain machine learning.

Automation, Drug research, Customer engagement, Supply chain optimization, Predictive maintenance, Operational effectiveness, Workforce effectiveness, Fraud detection, Resource optimization

### Vendors

Alteryx, Amazon Web Services, Domino Data Lab, Google Cloud Platform, H2O.ai, IBM (SPSS), KNIME, Microsoft (Azure Machine Learning), RapidMiner, SAS

### Market Penetration

5% to 20% of target audience



nationalgrid Gartner

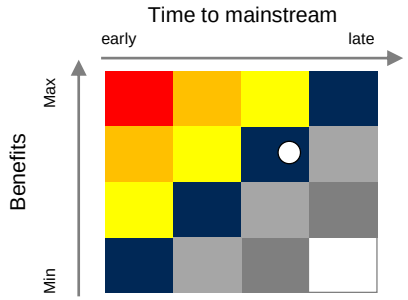
# Utility Industry Hype Cycle

## Bimodal IT

### Definition

Bimodal IT refers to having two modes of IT, each designed to develop and deliver information-intensive and technology-intensive services in a different way. Mode 1 — the traditional mode — emphasizes safety, stability and reliability, and usually is associated with operating the "run the business" part of the IT portfolio, Mode 2 — the nonlinear mode — emphasizes the speed and agility required for transformational and even experimental business aspects, such as enabling utility transformation into digital business.

### Priority Matrix




### Justification

Many utility CIOs are challenged to deliver stability for critical IT applications that support the core utility business — reliable, ubiquitous and economically priced commodity services provided on customer premises — and to support the innovation required by the emergence of prosumers and sector digitalization at a much faster pace. Gartner research shows that utility CIOs continue to plan the return on their IT investments with very long payback periods — typically five years or more. While this may have been appropriate in a less-dynamic and less-competitive environment, it certainly is not good enough for today's rapidly changing utility market.

### Impact

By recognizing that two different approaches are needed to enable their organisations to run at two speeds, utility CIOs will be better positioned to balance legacy modernization and innovation. They also will be able to deliver IT services for the emerging digital business in the utility sector, while retaining the operational efficiency and risk mitigation capabilities required to provide essential utility services. This will help IT improve relevance in the new era of digital business.

### Vendors

N/A

### Market Penetration

5% to 20% of target audience




nationalgrid Gartner

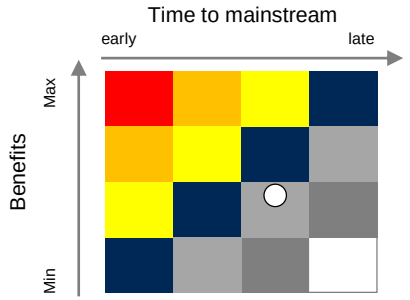
# Utility Industry Hype Cycle

## Mobile Customer Interaction Channel

### Definition

The mobile customer interaction channel enables utilities to deliver information and services to customers using smartphones or tablet computers. Communications and services delivered via SMS are also included. It also includes responsive design websites that render well on mobile devices as well as native applications for leading mobile operating systems including Apple iOS, Google Android, Samsung Bada and Research in Motion BlackBerryOS.

### Priority Matrix




### Justification

An increasing number of utilities are deploying mobile applications and expectations because future, not yet realized, deployment remains high. Common features include outage-related customer communications and the ability for customers to view consumption as well as to view and pay bills using their mobile devices. However, many utilities face challenges driving application downloads and ongoing use — due to limited app functionality and stickiness — as well as challenges with quality and reliability.

The SMS channel also remains important because it provides immediate access to some utility services without an application download. Increasingly, vendors are providing secure SMS payment capabilities, and meter-to-cash capabilities have also appeared. SMS can also play an important role in bill presentment and payment and in proactive alert messaging as a part of demand-response or energy-efficiency programs. Responsive design websites provide a user-friendly environment without the need for an app download.

### Impact

Mobile customer interaction channels impact customer-facing functions and customer experiences. Outbound notification in voice and video via mobile can reduce call centre volumes and enhance marketing performance. It can also increase adoption of electronic billing and other utility programs and services. Adding support for outage communications to the mobile channel can have a significant positive impact on customer experience during outages.

### Vendors

Capgemini, CGI, Kubra, Oracle, PlanetEcosystems, Tio Networks

### Market Penetration

5% to 20% of target audience



nationalgrid Gartner

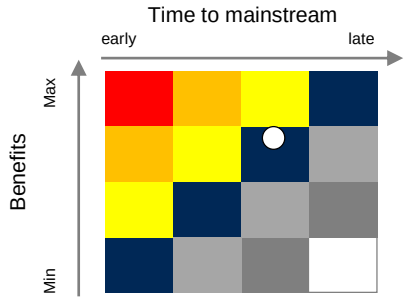
# Utility Industry Hype Cycle

## Lidar

### Definition

Lidar (light detection and ranging) is an optical remote-sensing technique for precisely scanning surfaces from a distance with laser light. Lidar systems use an active optical sensor that transmits laser beams and calculates ranges and the precise position of the target. Measurements are combined into a point cloud dataset, which is registered to a 3D-coordinate system.

### Priority Matrix




### Justification

Lidar data acquisition options continue to expand due to innovation in autonomous vehicle systems, unmanned aerial systems and security systems. Manufacturers of data acquisition systems in these industries are adding onboard chips that include neural-network-based processing for fast feature recognition and decision making. This chip-level innovation will expand the capabilities and value of lidar data collection.

Lidar data is most often collected, postprocessed and sold by surveying organisations to energy and utility organisations through data service contracts. Public-sector organisations, utility organisations, and architecture, engineering and construction (AEC) organisations are the largest consumers of lidar point cloud datasets. Most vendors originally providing surveying services and data have refocused on providing lidar datasets, seeing new growth opportunities with the aging of public infrastructure and the arrival of new regulatory mandates.

### Impact

Transmission grid operation organisations will be impacted the most by the benefits and costs of lidar. organisations that own or operate transmission facilities will use lidar to track vegetation growth, to rate transmission capacity and to mitigate service interruptions. organisations in the wind energy industry will use lidar for wind measurement. Land management organisations can use lidar to ensure compliance with rental contracts and to avoid easement violations.

### Vendors

AeroTEC, GeoCue Group, GeoDigital, Hexagon, RIEGL USA, Teledyne Optech, Topcon Positioning Group, Trimble

### Market Penetration

20% to 50% of target audience




nationalgrid Gartner

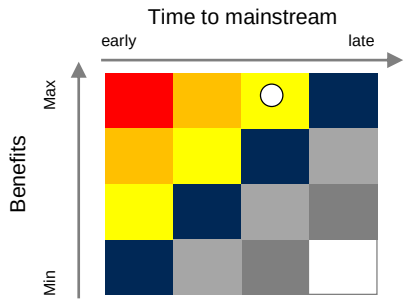
# Utility Industry Hype Cycle

## Internet of Things in Utilities

### Definition

The IoT is the network of dedicated physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment. IoT comprises an ecosystem that includes endpoints, communication protocols, applications, data and analytics. It is a core building block for digital business and digital business platforms. Vertical utility IoT includes advanced metering infrastructure and some form of connected operational technology such as supervisory control and data acquisition (SCADA).

### Priority Matrix




### Justification

Industries vary widely in their IoT technology adoption, ranging from services industries with limited adoption, to the utility industry, which leads all other sectors in adoption — based on Gartner market research. Gartner's 2018 CIO survey indicated that 59% respondents of utility companies have deployed IoT or are actively experimenting. Furthermore, utility organisations have begun to shift from a more technology-centric view of IoT in favour of a more business operations centric approach. One of the more developed use cases is advanced metering infrastructure in utilities. Consumer technology examples relevant to utilities include smart thermostats, home energy management and building energy management devices and systems, smart irrigation systems and smart appliances.

### Impact

Key business objectives such as cost reductions and process improvements will drive management to adopt IoT-based initiatives. IoT is inevitable and has cross-cutting impacts across the entire utility value chain. It also impacts customers and creates new opportunities to connect utility OT with information technology (IT), consumer technology (CT) and energy technology.

### Vendors

Blue Pillar, GE, Itron, SAP, Silver Spring Networks

### Market Penetration

20% to 50% of target audience



nationalgrid Gartner

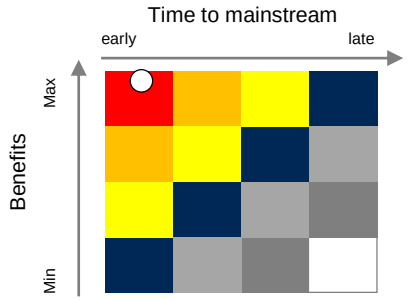
# Utility Industry Hype Cycle

## API economy

### Definition

The API economy is a set of business models and channels. It is based on secure access of functionality and exchange of data to an ecosystem of developers and the users of the app constructs they build. It is offered through APIs, either within a company or using the internet, with business partners and customers.

### Priority Matrix




### Justification

APIs have always been everywhere, but they were rarely used by anyone other than the development group that designed them. The basic principle of the API economy is that APIs can be new products that a company offers to open new business channels, advance a digital transformation, entice an ecosystem of partners or to sell more of its traditional products.

When we use a smartphone app, or book a ticket for our favourite concert, we use APIs — we live in an API economy already. As companies execute digital strategies, and smart devices consume APIs, this is only going to grow.

The API economy has established itself, as a precursor of digital strategies, and the primary way to grow an ecosystem. It has now passed the Peak of Inflated Expectations, the hype is decreasing, and it is sliding quickly into the Trough of Disillusionment. Even if fewer people talk about the API economy today, everybody realizes the role of APIs in digital transformations, and the original concept of the API economy lives on.

### Impact

A platform offering APIs is the basis of a digital strategy, and companies will either use somebody else's platform (thus being part of one of more ecosystems) or build one, creating a fresh ecosystem using it. APIs provide the technical foundation to a platform business.

### Vendors

N/A

### Market Penetration

20% to 50% of target audience




nationalgrid Gartner

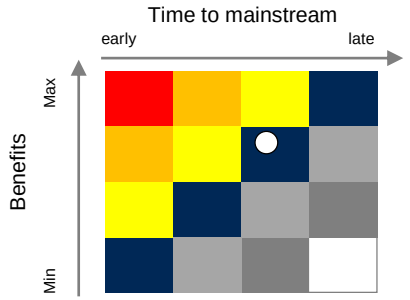
# Utility Industry Hype Cycle

## Meter Data Analytics

### Definition

Meter data analytic products offer analytical functionality that leverages advanced metering infrastructure (AMI)-generated consumption and event data, to provide insights into operational performance of metering systems, as well as distribution networks (such as hot socket, meter tampering or last gasp), or to indicate anomalies in consumption patterns and energy theft. They are increasingly being used to provide insights into network asset loading, to help anticipate abnormal events and to avoid failures.

### Priority Matrix




### Justification

Meter data analytics is a separate, although adjacent, technology market from meter data management (MDM) products. Although a number of MDM vendors have extended their products to provide analytical capabilities, MDM products are transactional, aimed at providing validation editing and estimation (VEE) persistence and dissemination functions.

Smart metering is an example of a vertical instance of the Internet of Things (IoT). As such, it is a key enabler of digital business transformation in the utility sector. Smart metering deployment is the main contributor to utilities' perception of the smart-grid data deluge coming their way. From the perspective of size, AMI deployment increases metering data volume by five orders of magnitude. The increased volume of data generated by edge devices (such as smart meters and smart thermostats) is not only challenging data storage capability, but also requires different types of analytics that can operate on streaming data, and use big data and extreme information-processing analytics capabilities.

### Impact

Consumption data is moving from its traditional, compartmentalized use in "meter to cash" process into an enterprise IT asset role. Consequently, meter data analytics can impact network operations (such as distribution network management), commodity management (demand response, consumption anomaly detection and load forecasting, for example), revenue management (such as revenue assurance), customer service and new product offerings in competitive energy markets.

### Vendors

C3 IoT, GE Energy Connections, Nokia, Oracle, SAP, SAS, Sensus (Verdeeco), Siemens

### Market Penetration

5% to 20% of target audience



nationalgrid Gartner

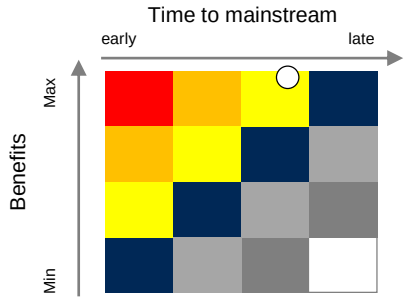
# Utility Industry Hype Cycle

## Big Data

### Definition

Gartner defines big data as high-volume, velocity and/or variety of information assets demanding cost-effective, innovative forms of information processing that enable enhanced insight, decision making and process automation. In the utility context, the ability to combine and analyse IT data, operational technology (OT) machine data and data generated by consumer Internet of Things (IoT) will be a critical requirement for digital business transformation.

### Priority Matrix




### Justification

Big data, so far, has focused primarily on the volume issues of extremely large datasets generated from technology practices such as social media, OT, internet logging and streaming sources. We are beginning to see more aggressive behaviour by organisations starting to address variety. Gartner surveys indicate that interest in social profile data and social chat data continues. In asset functions, OT and machine data are reported as the third-most-prevalent "variety" of data across multiple industries.

The energy and utility sector, because the practices are developing quickly, continues to descend into the Trough of Disillusionment, as conflicting concepts of what it is and how organisations can benefit from its management and analysis continue. Given the gathering theme of decentralization in the utility sector, the number of devices connecting to both electricity and data networks is set to grow substantially. With this in mind, solutions to manage and analyse the data from these devices will add to the big data uptake in utilities.

### Impact

In the utility context, big data is usually discussed in conjunction with the anticipated "smart grid data deluge." There are three principal aspects to big data. First, the quantitative aspects of big data generally do not emerge one by one. Volume, variety and velocity most often occur together. The second aspect is that innovation must be cost-effective to deploy and maintain. Finally, the focus must be on increased insight by the business into process optimization, from immediate automation to the development of completely new business models. The primary use cases emerging are leveraging social media data, combining OT data (machine data) with back-office and business management data, and further validating existing assets (increasing their "fidelity").

### Vendors

Cloudera, Dell EMC (Greenplum), IBM, MapR Technologies, SAS, Teradata (Aster Analytics)

### Market Penetration

1% to 5% of target audience



nationalgrid Gartner

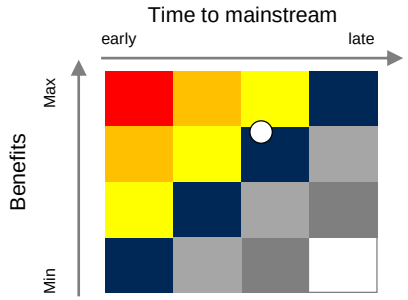
# Utility Industry Hype Cycle

## Consumption analytics

### Definition

Consumption analytics provides utility customers with energy usage insights. Techniques include benchmark customer comparisons, trend analysis, correlations with weather trends and disaggregation to estimate contributors to overall consumption, such as appliances, water heating, and space heating or cooling. This technology can be used to generate energy efficiency tips and recommendations. Also, it is customer-focused, as opposed to internally focused utility analytics, such as load forecasting for commodity and network planning.

### Priority Matrix




### Justification

Utilities are increasingly providing customers with consumption analytics as they focus on increasing customer engagement. Many U.S. utilities provide benchmark comparison reports in paper statements and online. Consumption analytics can be combined with expert rule engines to automatically generate conservation tips and energy efficiency recommendations. The advent of highly granular time interval consumption data from smart meters opens new possibilities for consumption analytics. For instance, time interval data enables energy consumption disaggregation. Energy consumption disaggregation is the use of analytics to infer the main categories of consumption (such as heating, cooling, lighting and appliances).

The consumption patterns and analytical needs of residential customers are different from commercial and industrial customers, which have more complex consumption profiles, and this drives segregation in the solution marketplace. While much of the focus for this technology has been on electricity consumption, it is also relevant for water and natural gas, and can act as a driver for water conservation or for fuel-switching programs.

### Impact

Consumption analytics can help utilities meet energy efficiency targets by encouraging consumers to change behaviours, or to invest in energy efficient appliances or weatherproofing. This technology can also be used to help customers select the best tariff based on historical consumption patterns, and to measure and validate energy efficiency improvements in jurisdictions with energy efficiency mandates. It can also be used to prevent high-bill complaint calls into call centres by helping customers understand why their consumption has risen.

Energy retailers can also use consumption analytics to differentiate through value-added services. In the future, consumption analytics could be used to tune demand response, and for ongoing distributed energy management. The continued trend of decentralization of energy provisioning will play a significant role in bringing consumption analytics into sharper relief as device/appliance specific analyses become more widespread.

### Vendors

Bidgely, C3 IoT, EnerNOC, ENGIE Insight, FirstFuel, ONZO, Oracle, PlotWatt, Tendril

### Market Penetration

5% to 20% of target audience



nationalgrid Gartner

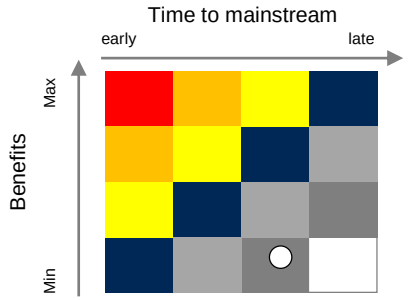
# Utility Industry Hype Cycle

## Emissions Position Management

### Definition

Emissions position management solutions for greenhouse gases (GHGs) are used to track emissions, manage any related emissions certificates and record associated trades. Basic emissions-monitoring solutions map the volume and type of fuel used in generation units, as well as factors associated with the unit's operation, to assess the emissions. More complete solutions provide reports for verification purposes and can factor in market prices for emissions to provide a financial perspective.

### Priority Matrix




### Justification

Many generators with fossil fuel assets track emissions and manage United Nations-approved emissions certificate inventories using spreadsheet-based solutions. Some enterprises use environmental, health and safety (EH&S) solutions for emissions position management. Where a cap-and-trade market for GHGs exists, the use of energy trading and risk management (ETRM) platforms to manage certificate inventories and record-related trades continues to grow. GHGs include carbon dioxide, sulphur dioxide, nitrous oxide and particulates. Stack-monitoring solutions can be used to assist in managing emissions position data.

### Impact

The primary affected area is the supply domain, with impacts on environmental compliance and ETRM functions. Because these documents can involve multiple inputs from separate business functions, there is the risk of user error. Given such risk, CIOs and IT leaders should be active in monitoring the process of emissions report production.

### Vendors

Accruent (Verisae), Allegro Development, Environmental Systems Corporation (ESC), FIS (SunGard), IHS Markit, Locus Technologies, Openlink, Triple Point Technology

### Market Penetration

1% to 5% of target audience




nationalgrid Gartner

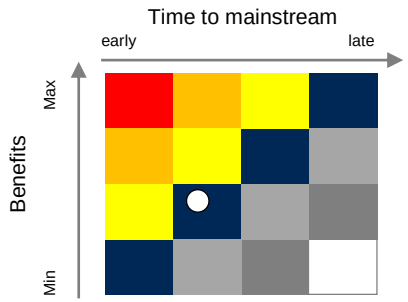
# Utility Industry Hype Cycle

## Social CRM

### Definition

In the utility context, social CRM is the use of social media to support customer and stakeholder interactions, thereby improving performance in key areas such as customer engagement, communications during outages, energy efficiency, billing and reputation management.

### Priority Matrix




### Justification

Most utilities have established a presence in popular social media channels, and have begun using social media as a customer interaction channel to augment other channels, such as call centres. Some leading-edge utilities have also implemented social media monitoring programs to protect their brand reputation and to monitor public sentiment on key issues such as smart metering deployment, renewable energy and ratemaking. Large-scale power outages, in particular, are a key driver of customer engagement with utility social media, as outages temporarily elevate the importance of utility social CRM.

Social CRM tools facilitate the management of utility social channels, including internal teamwork and collaboration to scale channel participation when necessary, such as during large-scale outages.

### Impact

Social CRM can improve communications during outages and customer service delivery. For example, utilities can collaborate with customers on the status of outages, for both outbound communications on restoration processes and to leverage customer-filed reports on network damages. Utilities can also drive energy conservation with social media, gamification and other techniques to realize cost-effective energy efficiency measures or to meet mandatory targets from regulators. Competitive energy retailers can also realize benefits by leveraging social media for customer acquisition, such as referral reward programs.

### Vendors

Conversocial, Hootsuite, Jive, Nimble, Salesforce, Spredfast, Sprinklr, Zoho

### Market Penetration

20% to 50% of target audience




nationalgrid Gartner

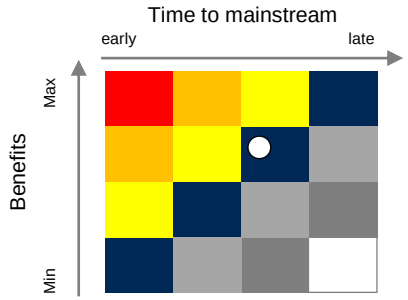
# Utility Industry Hype Cycle

## Advanced Distribution Management System

### Definition

An advanced distribution management system (ADMS) is a software addressing needs for electric distribution network management and optimization. ADMS functions available for electric utilities include distribution state estimation, fault location, isolation and restoration, volt/volt-ampere reactive optimization, outage management, conservation through voltage reduction, peak demand management, and integration of distributed energy resources.

### Priority Matrix




### Justification

ADMSs integrate the decision support environment for network operators across outage management, power network analysis and network operation needs. Operators of electric distribution networks use ADMSs for both regular (blue-sky) operations and abnormal (or storm recovery) modes of operation. ADMSs analyse power outage notifications, identify faults, reconfigure networks and support power restoration. Implementations can leverage information from smart meters as well as substation automation systems and devices located downstream on distribution circuits. Operators can use ADMSs to optimize the system against reliability targets and operational capacity constraints.

Gartner estimates ADMSs are monitoring electric service for over 700 million electricity customers worldwide. Yet the ADMS market is still a mix of commercial off-the-shelf (COTS) and customized project-specific implementations. Several ADMS vendors are demonstrating a strong, deliberate focus on mastering COTS development and delivery processes. Although software quality assurance and release management processes are improving overall, in most cases, the results are not yet evident in customer feedback.

### Impact

Full ADMS implementations can dramatically improve outage restoration and daily grid operations, and even defer the need for new power plant construction. Business leaders in distribution network operations, customer service and asset management will leverage ADMS capabilities to improve customer satisfaction (for example, through accurate prediction of restoration times) and distribution reliability (through real-time optimization of distribution network configurations).

While the earliest ADMS project successes were mostly at large, investor-owned utilities, ADMS adoption at smaller utilities is now growing as well. ADMSs are not directly applicable in gas and water utilities, but it is likely that ADMS vendors that serve those markets will introduce certain capabilities useful for operating those networks.

### Vendors

ABB, Advanced Control Systems, GE, Open Systems International (OSI), Oracle, Schneider Electric, Siemens, Survalent

### Market Penetration

5% to 20% of target audience




nationalgrid Gartner

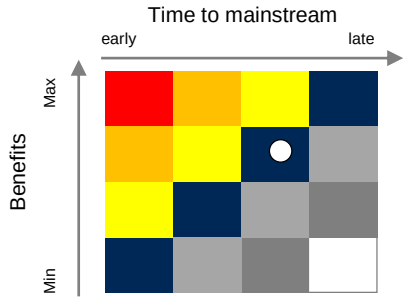
# Utility Industry Hype Cycle

## Industrial Operational Intelligence

### Definition

Industrial operational intelligence (OI) combines capabilities formerly found within other operations systems. Capabilities include the ability to capture, store and visualize time series data (from historian software), model assets and processes for business user context, provide situational awareness and initiate field actions, provide operations-focused analytics and offer support for asset performance management.

### Priority Matrix




### Justification

Industrial OI continues to be portrayed as the critical platform to monitor and add context to large volumes of multi-structured data and information from a diverse set of OT and IT data sources. It enables utilities to manage operational performance with a broader business context than is possible with individual SCADA systems, energy management systems, data historians or other plant and control centre applications.

In a sense, industrial OI recombines capabilities from these more mature applications into a new application category focused on getting more business benefit from operational technology (OT) data. Stand-alone legacy systems have not moved as quickly regarding the requirement to create and manage multiple data models, use data mining and discovery tools, and leverage advanced analytics to monitor and add context to volumes of multi-structured data and information spanning multiple OT and IT data sources.

### Impact

Industrial OI supports operational decision making in generation of plant management, transmission and distribution network operations. A key capability of industrial OI is to define and maintain persistent functional and operational models (or relationships) that create understandable business context for users.

The benefits that accrue from industrial OI will include more efficient and effective operations, better optimization of asset investments, and the ability to dynamically manage operational performance in the context of multiple constraints and a changing business environment. Industrial OI will also help mitigate operational risk. More timely management of data streams coming from historians and real-time production systems, combined with advanced analytics, will help utilities to uncover potential problems and begin developing better predictive capabilities.

### Vendors

ABB, AspenTech, Dassault Systèmes, GE Digital, OSIsoft, SAP, Schneider Electric, Seeq

### Market Penetration

20% to 50% of target audience




nationalgrid Gartner

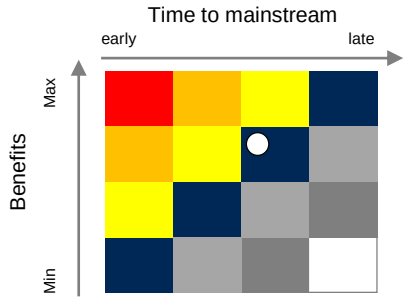
# Utility Industry Hype Cycle

## Cloud in Utilities

### Definition

Gartner defines cloud computing as a style of computing where scalable and elastic, IT-related capabilities are provided "as a service" to customers via internet technologies. An increasing variety of software functionality is available via SaaS and cloud, such as CRM, human resources management (HRM), enterprise asset management (EAM), asset performance management (APM) and mobile workforce management (MWM).

### Priority Matrix




### Justification

A number of enterprise application markets, such as CRM and HRM, have seen significant adoption of cloud deployment models in the past 10 years. The utilities industry, however, has seen limited adoption of cloud-based applications until recently. Expanding vendor offerings are changing the market dynamics. A large number of small vendors are disrupting the status quo by delivering low-cost, cloud-based enterprise applications to the market. The larger vendors are starting to take notice and deliver their own cloud products to the market. In addition, applications with high B2B content and collaboration are ripe for cloud usage.

### Impact

Cloud providers typically promise lower total cost of ownership (TCO), faster deployment time and broader enterprise wide adoption. In case a utility company does not have access to skill resources and technology platforms (such as big data analytics projects), cloud can be an appropriate mode to reduce time to market and provide quicker business benefit realization. Cloud is also emerging as a mechanism for obtaining technical and business services quickly and for scaling digital business capabilities.

### Vendors

Aspect Enterprise Solutions, C3 IoT, GE, IBM Tivoli (Maximo), OATI, Oracle, Salesforce, SAP

### Market Penetration

20% to 50% of target audience




nationalgrid Gartner

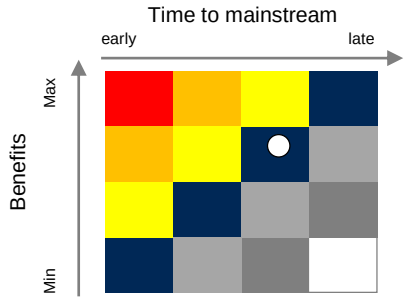
# Utility Industry Hype Cycle

## Demand Response Management Systems

### Definition

Demand-response management systems (DRMS) are applications for managing utility demand-response (DR) programs. Capabilities include enrolling customers and their load resources and planning, executing, optimizing, measuring and generating settlement payment amounts for DR events. The value and importance of DRMS will rise as the number and complexity of DR offerings and participating customers grow.

### Priority Matrix




### Justification

Demand for DRMS is highest in North America, which leads in DR adoption. Demand is concentrated among utilities that actively build and manage their own DR programs as opposed to solely outsourcing to ancillary services providers. However, DR programs exist and/or are under consideration in a number of markets globally, especially in geographies that face challenges in meeting future demand growth and in balancing intermittent renewable energy production and DERs.

Large-scale advanced metering infrastructure (AMI) deployments also buoy economic DR, as AMI provides interval consumption data, making it possible to measure changes in consumption during DR events. Demand for DRMS is increasing moderately in most markets. Marketplace rate of adoption is driven mainly by such factors as the integration of DERs, smart meters, electric vehicles with smart grids and regulatory change promoting the adoption of DR and increasingly automated demand response (ADR).

### Impact

Areas of utility operations that can benefit from DRMS include retail, supply and resource adequacy planning. Some advanced distribution management systems can integrate with DRMS to make demand response an effective operational measure for targeted distribution network optimization.

### Vendors

ABB, AutoGrid, GE, Itron, Nexant, Schneider Electric, Siemens

### Market Penetration

5% to 20% of target audience




nationalgrid Gartner

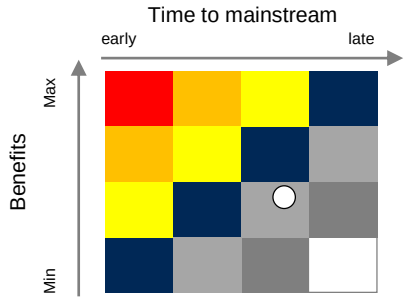
# Utility Industry Hype Cycle

## Transmission Outage Management

### Definition

Transmission outage management (TOM) systems coordinate planned outages in the generation and transmission grid. TOM assesses scheduling options in light of expected network conditions. Outage requests are received from transmission operators or other stakeholders. The TOM application set is distinct from outage management systems (OMS), the industry name for applications focused on emergency restoration activities in the distribution network. TOM is also different from generation outage management which is used for scheduling plant outages.

### Priority Matrix




### Justification

TOM continues to be an immature software market, with fewer than 150 installations reported by vendors. The most mature installations utilize transmission planning models to accurately assess the operational impact of outages on transfer capacity. TOM supports a centrally administered workflow process that is accessible by all stakeholders within a planned outage, whether reliability coordinators, transmission operators or merchant generators. TOM serves as a central hub for planning, submitting and tracking outage requests. It also provides automated notification to internal and external parties for outage entry and state transitions.

### Impact

TOM products affect the generation and delivery domain as well as independent system operators responsible for maintaining transmission system availability and generation resource adequacy. TOM is used by a wide range of professionals — outage coordinators, power grid dispatchers, power line technicians, protection, control and safety engineers, control centre staff and corporate management. The TOM production workflow helps them to communicate effortlessly, making decisions quicker and with more confidence.

### Vendors

ABB, Equinox Software Design, MCG Energy Solutions, Nexant, OATI, Sun-Net

### Market Penetration

5% to 20% of target audience



nationalgrid Gartner

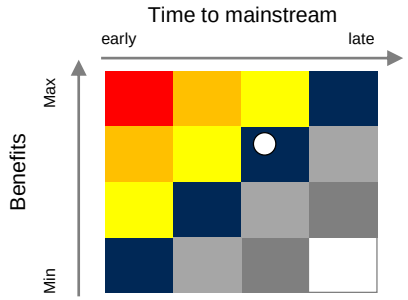
# Utility Industry Hype Cycle

## Asset Performance Management

### Definition

Asset performance management (APM) is a market of software tools and applications for optimizing operational assets (such as plant, equipment and infrastructure) essential to the operation of an enterprise. It uses data capture, integration, visualization and analytics to improve operations, maintenance timing, and which maintenance and inspection activities to perform on mission-critical assets. APM includes the concepts of asset strategy and risk management, condition monitoring, predictive forecasting and reliability-centred maintenance.

### Priority Matrix




### Justification

Some aspects of APM have been practiced for more than 10 years, mostly by the largest companies in a handful of industries. Its broader adoption has been stalled until recently by a combination of internal and external factors, including provable ROI, budget access, skills, delegation of responsibilities and maturity of technology. Previously, there was a need to build your own or apply complex mathematical tools to the problem.

Recently, APM has become more productized and is maturing into a more accepted part of business. This is, in part, due to rapid innovation in enabling technologies such as IoT, advanced analytics and algorithms in asset-intensive industries. These are widening the scope and decreasing the deployment cost, aiding more widespread awareness and use of APM. The promise of reduced maintenance cost and downtime, coupled with higher levels of operational reliability, is attracting other industries. APM adoption is progressing at a varied pace among industries. Those that depend on the success of their assets such as manufacturing, utilities and natural resources industries tend to be further along in their asset management strategy, and usually invest more heavily in APM. Other industries that rely on physical assets to some degree, such as retail and public sector, are beginning to embark on this journey, but may not invest as heavily in APM solutions.

### Impact

APM is a critical investment area for asset-intensive industries, including manufacturing, mining, oil and gas, transportation and utilities. Successful APM deployments can deliver measurable improvements in availability, as well as reduce maintenance and inventory carrying costs. Most APM projects are executed on the premise that data-driven decisions will improve equipment reliability and, therefore, reduce operational risk. Some benefits include improved uptime and cost savings can be substantial, typically delivering benefits measured in millions of dollars per year.

### Vendors

ABB, AspenTech, AVEVA, Bentley Systems, GE Digital, IBM, MaxGrip, SAP, SAS, Siemens

### Market Penetration

20% to 50% of target audience




nationalgrid Gartner

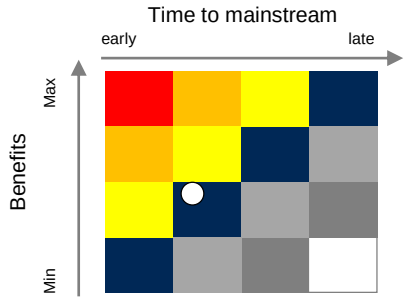
# Utility Industry Hype Cycle

## Asset Investment Planning

### Definition

Asset investment planning (AIP) is a form of decision support tool that produces plans for investing capital in large-scale physical infrastructure, such as utilities and transportation systems, over extended time horizons (typically extending beyond current budget cycles and up to 10 years or more). It incorporates data on asset condition, maintenance costs, criticality, budgets and risks, and then analyses it to identify optimal investment plans, including asset and system upgrades, refurbishment, replacement or new infrastructure.

### Priority Matrix




### Justification

Until recently, utilities' adoption of commercial off-the-shelf (COTS) AIP applications has been limited. Three barriers have held AIP investment back: (1) lack of awareness, (2) immature COTS AIP solution market and (3) lack of financial or regulatory incentives. Previously, organisations defaulted to utilizing Microsoft Excel or project management applications, however, these solutions have limitations such as not being able to understand impacts of asset-related risks, and these systems are not designed to deal with effects of time on asset condition and, furthermore, investment decisions.

### Impact

AIP positively impacts capital planning, financial budgeting and asset operations by informing better asset investment decisions based on data, that is data on asset condition, maintenance costs, criticality, budgets and risks, and then analyses it to produce capital investment plans over extended time horizons as opposed to rules of thumb or past experience.

In general, AIP tools provide consistent processes and methodologies for energy and utility companies to prioritize capital and maintenance spending to align with corporate strategies, giving business units and corporate officers a common understanding of the business risk effects of cost-cutting initiatives.

### Vendors

Clevest, Copperleaf, Cosmo Tech, PowerPlan, SEAMS

### Market Penetration

1% to 5% of target audience




nationalgrid Gartner

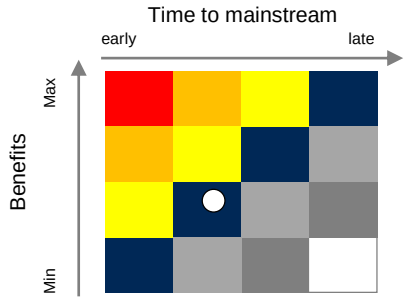
# Utility Industry Hype Cycle

## CIM Integration Standards

### Definition

The Common Information Model (CIM) is an International Electrotechnical Commission (IEC) standard (primarily contained in standards 61968 for distribution, 61970 for transmission and 62325 for markets). These standards express utility domain objects in Unified modelling Language (UML). Utility architects with information modelling tools can use the CIM as a canonical data model. Their methods are often referred to as "model-driven integration."

### Priority Matrix




### Justification

Utility application portfolios are constantly changing as new business needs arise and legacy applications are retired. Successful integration of new applications into existing environments or the extension of business processes into outsourcing arrangements and new market entities requires close attention to business vocabulary. Different applications invariably describe the same utility "objects" in different ways.

Utility and vendor adoption of CIM is steadily increasing for distribution operations, advanced metering infrastructure (AMI), work management and advanced distribution management. Vendor participation in global interoperability testing continues to increase. Adoption of CIM in North America has been on a slow, steady rise for years, but utilities in other nations and on other continents have shown faster adoption rates. Grid authorities in China, Russia and Europe are mandating the use of CIM, and interest is growing in Australia and South America.

### Impact

The precise specification of the CIM can reduce the "distance to integrate" for utility projects and provide a well-orchestrated migration to contemporary architecture patterns. CIM profiles that specify a subset of the CIM classes and attributes are available to help project teams adapt the CIM to specific business contexts and drive automated message payload design directly from design tools. Cross-functional business processes (for example, transmission grid management, distribution operations, outage management and enterprise asset management) and collaborative intercompany processes (such as power model exchange, energy trading, supply chain management and outsourced inspection/maintenance) will benefit the most from CIM-based integration. CIM-based integration will also be valuable with the growth of distributed energy resources.

### Vendors

ABB, Accenture, Capgemini, GE, IBM, Saudi Industrial Services Co. (SISCO), Siemens (Energy), Xtensible Solutions

### Market Penetration

5% to 20% of target audience




nationalgrid Gartner

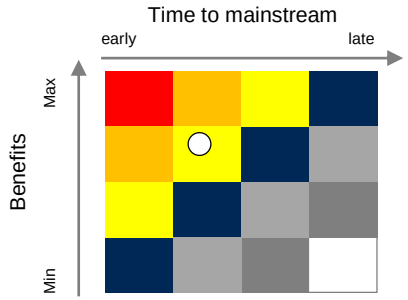
# Utility Industry Hype Cycle

## Field Service Workforce Optimization

### Definition

Field service workforce optimization is the ability to optimize the planning and dispatch of complex teams of field service technicians through software algorithms and machine learning that incorporate technicians' skills, previous results, SLAs, issue severity, travel conditions, parts availability and business rules. This technology profile is focused on field services performed on customer-owned equipment at a customer site, rather than on company-owned equipment in its physical plant.

### Priority Matrix




### Justification

The need to improve equipment uptime and optimize personnel utilization, fuel, overtime, shift coverage and travel time, as well as take in work demand from additional channels such as IoT, EAM and chat, is driving the adoption of optimization software and processes. New cloud-based applications have emerged, best-of-breed vendors have consolidated with larger organisations, and some older applications are being rewritten as web services that other applications can consume.

In low volume scheduling cases, new optimization functionality included in some FSM products is suitable. For complex cases, multivendor field service solutions (with an FSM vendor and a workforce optimization vendor) are forming as CRM, ERP and best-of-breed FSM vendors partner with field service workforce optimization vendors.

### Impact

Field service workforce optimization addresses a business's need to reduce the number of dispatchers sending out field service technicians, handle more demand with the same base of technicians, lower the levels of spare-part inventories, and improve the accuracy and communication of arrival times and statuses. These factors improve customer satisfaction and loyalty.

organisations can improve profitability not only by decreasing costs, but also by increasing revenue through recommendations for additional service made by trusted technicians who are better-informed about service history and manufacturer recommendations. In addition to these benefits, organisations can use the data to build metrics and rank technicians, such as by the average time to complete tasks, the average utilization rates and the average first-time fix rates. This provides a means to identify star performers who can help improve the productivity of other technicians through training and mentoring.

### Vendors

Accruent (Verisae), ClickSoftware, IFS, Oracle, ServicePower

### Market Penetration

20% to 50% of target audience




nationalgrid Gartner

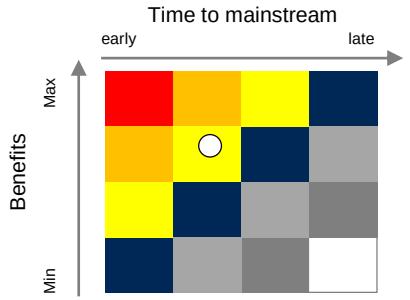
# Utility Industry Hype Cycle

## Wholesale Market Operations

### Definition

Wholesale market operations are broadly defined as market interfaces, settlements, scheduling, bid management or bid optimization, transmission billing, and forecasting. The existing and emerging wholesale market structures require trade partners to communicate and transact business seamlessly. The wholesale market operations (sometimes called "bid to bill") software needs to address access control, scalability and flexibility to meet market changes and regulatory requirements.

### Priority Matrix




### Justification

Wholesale market maturity is highly disparate worldwide. The most mature markets are in eastern Australia, the Nordic countries, Singapore, the U.K., and portions of the U.S. and Canada. Other major markets are embarking on wholesale market design following retail restructuring, or they have retracted from market restructuring significantly following failed retail restructuring initiatives. Efforts are underway to normalize wholesale market conditions worldwide, providing for congestion management and pricing — ultimately, moving from zonal to nodal pricing (locational marginal prices or LMP).

In addition, most markets are introducing long-term pricing signals, such as the reliability pricing model (RPM), to address long-term investment incentive in developing the new sources. The proliferation of the wholesale market-level demand response (DR) programs in many markets has created new requirements to integrated DR as a resource in the overall wholesale capacity market. This consequently leads to a new interaction requirement between wholesale market operation suites and wholesale-level-focused demand response management systems.

### Impact

The supply domain is the area of greatest impact — that is, primarily functions associated with market integration and communications, finance, risk, and regulatory and compliance reporting.

### Vendors

ABB, CGI, FIS (SunGard), GE, Integ Enterprise Consulting, Nexant, OATI, Siemens

### Market Penetration

20% to 50% of target audience




nationalgrid Gartner

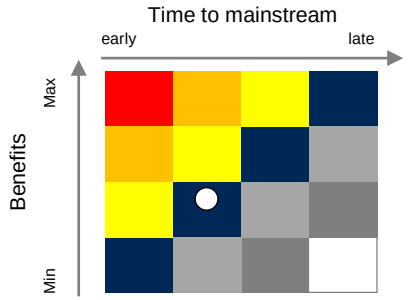
# Utility Industry Hype Cycle

## Business Process Outsourcing

### Definition

Business process outsourcing (BPO) is the delegation of one or more business processes to an external provider that owns, administers and manages the selected processes via a technology platform under its own control. BPO is based on defined and measurable performance metrics.

### Priority Matrix




### Justification

Historically, the key appeal of outsourcing for utilities operating in developed economies has been one of achieving economies of scale in a fragmented utility market with the ultimate goal of cost reduction. The second driver, in some cases, is cost management through the ability to transform the fixed cost (capital expenditure) of IT infrastructure and the application environment into a variable cost (operating expenditure) by paying as you go.

This usually helps new entrants in competitive retail markets to scale their operation without large upfront investment in retail technology platforms. Utilities are increasingly exploring new products and services as the decentralization of energy provisioning grows. In this context and set against shrinking retail supply margins, the case for outsourcing, or revisiting existing arrangements, may become stronger in some regions, as a means of cost optimization.

### Impact

BPO affects customer service, billing, HR, finance and accounting, and the supply chain. There are also examples of BPO (offshoring) for the utility delivery segment, such as map digitizing and GIS data management.

### Vendors

Accenture, Capgemini, Hewlett Packard Enterprise, IBM, Infosys, VertexOne, Wipro

### Market Penetration

20% to 50% of target audience




nationalgrid Gartner

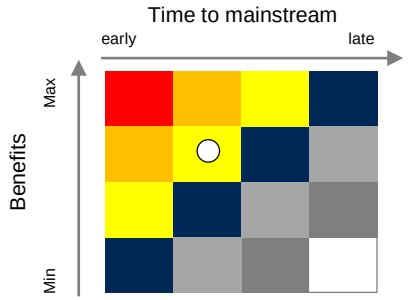
# Utility Industry Hype Cycle

## Meter Data Management

### Definition

Meter data management (MDM) products are IT components of the advanced metering infrastructure (AMI) responsible for cleansing, calculating and providing data persistence, as well as for the dissemination of metered consumption data, which can be used to support billing, load profiling, forecasting, asset loading and a variety of analytic use cases. They are software products used for the management of metered consumption data, which can be used across the enterprise and shared with customers, partners, market operators and regulators.

### Priority Matrix




### Justification

Digital transformation of the utilities is driving the need for multipurpose metering data repositories that can meet requirements outside of metering data's traditional use in a "meter to cash" (revenue management) process. MDM, as an AMI IT component, and as a separate IT product category, is leading AMI adoption because many utilities perceive MDM as a more-mature, less-expensive and, consequently, a less-risky technology selection than, for example, AMI communication or meter technology.

### Impact

Affected areas include energy commodity management, load forecasting, distribution asset utilization, revenue management (meter to cash) and customer service. Given the current primary use of meter data as an input to the monthly billing and settlement process, the new requirements have impacted metering technology requirements, as well as processes and organisational structures. It elevates metering from simply a component of the revenue-processing life cycle (meter to cash) to an enterprise function supporting multiple uses of consumption data in other key process life cycles, such as asset management (optimal network configuration and loss minimization), commodity management (load profiling and forecasting) and CRM (customer segmentation based on static load profiles and response to variable pricing signals).

### Vendors

Cuculus, Honeywell (Elster), Itron, Landis+Gyr, Oracle Utilities, Siemens (eMeter)

### Market Penetration

20% to 50% of target audience




nationalgrid Gartner

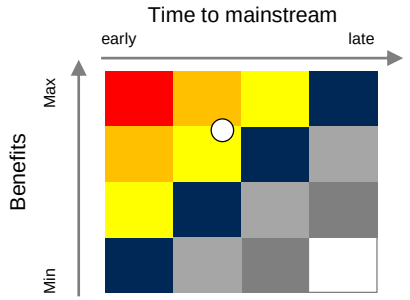
# Utility Industry Hype Cycle

## Load Forecasting

### Definition

Load forecasting is a utility application that minimizes risk by predicting future consumption of commodities transmitted or delivered by the utility. Techniques include price elasticity, weather and demand-response/load analysis. Forecasts must use regional customer load data, with time series customer load profiles. Accurate forecasts require adjustments for seasonality. Distribution load forecasting must be reconciled with distribution network configuration as part of the distribution circuit load measurements.

### Priority Matrix




### Justification

Load forecasting is a key functionality required by utility companies to successfully manage the commodity life cycle. Higher adoption of distributed generation by consumers, including growth in renewable generation (wind and solar power) and electric vehicles (EVs), requires new forecasting models that are capable of integrating generation contributions from intermittent renewable energy sources that are not dispatchable. The potentially significant impact of demand-response initiatives, as well as the price sensitivity of load resources, also needs to be modelled and included as a component of the overall load forecasting discipline. Improvements in the performance of general forecasting and analytical tools are filtering into load forecasting solutions. This enables the use of wider simulations and scenarios involving variables associated with future load or demand. Advanced metering infrastructure (AMI) systems are also generating highly granular energy usage data useful for forecasting distribution loads, planning demand-response actions, and generally improving the accuracy and detail of load forecasts.

### Impact

Affected areas include retail, supply and energy commodity management, as well as transmission and distribution asset investment planning and design. Forecasts often depend on load data from multiple sources, such as consumption data from meter data management for the distribution level or data from a historian database for the transmission level. At the distribution level, forecasts must reflect the actual distribution network configuration at peak load periods.

### Vendors

ABB, IBM, Itron, Oracle, SAS

### Market Penetration

More than 50% of target audience




nationalgrid Gartner

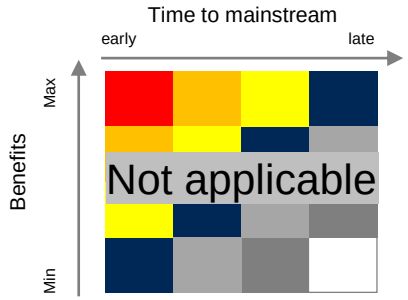
# Utility Industry Hype Cycle

## Outage Management Systems

### Definition

An outage management system (OMS) is a utility software application that models network topology for safe, efficient field operations related to outage restoration. OMSs tightly integrate with call centres to provide outage information, supervisory control and data acquisition (SCADA) systems for switching and breaker operations, and meter data management systems to receive Power Off notification and for virtual call-back notification. OMS tracks, groups and displays outages to safely and efficiently manage service restoration activities.

### Priority Matrix




### Justification

Extreme weather events, combined with aging infrastructure resulting from protracted low-investment levels in the utility delivery infrastructure, are straining utility companies' ability to meet mandated customer service levels. OMS solutions improve outage restoration business processes, track customer impacts and provide historical outage reporting for the calculation of reliability indexes.

Classic outage determination procedures relied on network-tracing schemas to associate customer outage calls with the operation of upstream protective devices. Now, OMSs must manage power outage notifications from smart meters and many other distribution sensors. Geographic information systems (GISs) are essential to providing a network connectivity model. OMSs require substantial integration with many other systems as well, including enterprise asset management, to better manage work and the associated financials. Integration with advanced metering infrastructure (AMI) enables automated outage notifications and also a virtual call-back function — contacting customer meters directly to verify restoration. Enterprise service bus architecture with standards-based, model-driven integration enables effective integration with related business systems.

### Impact

Distribution network operation centres use outage management systems to analyse outages and dispatch crews, and will want to implement OMS capabilities. Customer-facing applications in customer service centres will be impacted significantly, in particular when OMS updates are delivered through social media channels. Metering organisations that work with smart meters will be working with OMS project teams to integrate smart meter power on notifications (aka last gasp) with outage restoration processes. Distribution reliability engineers will use the outage reporting and analytics functions of the OMS to identify required improvements to distribution maintenance plans and vegetation management plans.

### Vendors

ABB, CGI, GE, Intergraph, Milsoft Utility Solutions, Oracle, Schneider Electric, Trimble

### Market Penetration

More than 50% of target audience




nationalgrid Gartner

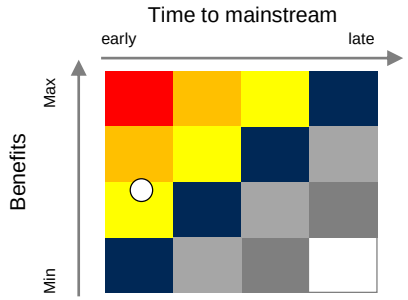
# Utility Industry Hype Cycle

## Distribution Design Tools

### Definition

Distribution design tools cover several areas, including work sketch preparation/editing, workflow management, cost estimating/bill of materials (BOM)/asset management, engineering analysis (technical design validation) and design optimization (automating the sizing and placement of new assets). Products in this category are offered by GIS-based infrastructure management solution vendors, enterprise asset management (EAM) system vendors and dedicated independent software vendors (ISVs).

### Priority Matrix




### Justification

The importance of distribution network design is becoming increasingly important with the growth of distributed energy resources. Distribution-connected solar photovoltaic equipment, consumer energy storage and pluggable electric vehicles are introducing two-way power flow into a system previously designed for one-way flow. Regulatory agencies expect utilities to proactively manage the integration of these resources into the distribution network.

Drivers for growth in this market include aging assets, an aging workforce and decreasing demand. Improved energy efficiency along with prosumer growth is softening demand growth, thereby limiting capital budgets. Engineers must be more precise in their network designs as assets reach capacity limits. Design tools are becoming increasingly smart and mobile, incorporating imagery within the design and adopting 3D workflows. Some solutions incorporate image analytics for identifying asset characteristics and placement (such as conductor size and clearance measurements).

### Impact

Feeder construction and service connections create significant workload for utilities with growth in their territories affecting corporate profitability. Good design tools can lower engineering costs, boost operational efficiency and improve service reliability within capital budget constraints. Utility engineers that can consistently apply equipment standards and optimize distribution designs should realize incremental capital savings on new distribution line extensions and lower costs per new connection. Also, distribution design tools help ensure the utility has accurate metadata about distribution system assets captured at the point of design. Data accuracy is essential for accurate network analysis and is also the key for success of smart grid initiatives.

### Vendors

Autodesk, Bentley Systems, GE, Hexagon (Intergraph), Schneider Electric

### Market Penetration

20% to 50% of target audience

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