Annex

A7-8.03 – Whole Systems

December 2019

As a part of the NGET Business Plan Submission

nationalgrid

RIIO-T2

nationalgrid
Electricity Transmission

A7-8.03 – Whole Systems

Submission annex

9th December 2019

Executive Summary

The need for industry to take a more explicit whole system view was emphasised in the *RIIO-2 Sector Specific Consultation* document. In this annex, we set out how we have embraced whole system thinking to date, built a whole system draft business plan for the T2 period, and what more could be done to deliver consumer benefit through the price control:

- **How we have embraced whole systems to date**. Here we emphasise that taking a whole system approach is not new. We show that consumers have saved £90m – £108m in the T1 period through collaborative work with Distribution Network Owners (DNOs) to use Active Network Management schemes as opposed to investment in transformers. We emphasise ways of working with a wide spectrum of stakeholders, including how we are working with industry to protect the network from external threats, further innovation and develop a strategic network of fast en route Electric Vehicle charge points

- **How we have built a whole system business plan submission for the T2 period**. We draw on eight examples showing whole system solutions across our submission:

  1) Managing high fault levels from increased levels of distributed generation – **reducing our baseline proposals by £105m** through DNO collaboration
  2) Managing high voltage by investing in reactive compensation assets – **reducing our baseline proposals by at £184m** by building our plan in a whole system manner
  3) Our work with UK Power Networks (UKPN) to optimise network spend to manage a security of supply and asset health issues
  4) Coordinating asset replacement with UKPN in London – **saving £25m** overall
  5) Optimising the Dinorwig- Pentir cable replacement by taking a whole system approach with the Electricity System Operator (ESO)
  6) Our work with the ESO to determine our investment to ensure the system is operable in a zero-carbon future
  7) Taking a whole system approach to projects proposed through the Network Innovation Allowance
  8) Working with the Black Start Restoration Group to define our investment level to meet requirements of the impending updated restoration standard

- **How the price control could deliver more whole system solutions.** We put forward proposals for a mechanism that would allow Transmission Owners (TOs) to utilise asset flexibility to provide services to the Electricity System Operator (ESO) for reducing constraint costs. We additionally put forward proposals for Anticipatory Investment for whole system solutions to enable net-zero targets. We welcome Ofgem's decision in the *RIIO-2 Sector Specific Methodology Decision (May 2019)* on the three mechanisms it will use in RIIO-2 to encourage the emergence of more whole system solutions.

There is more whole system value to be uncovered in the T2 period, especially in areas where the exact volume and scope of work required is uncertain. To fully realise this value, industry must continue to work together to coordinate the reform of processes, ways of working and incentives which encourage their emergence. We are committed to working with all stakeholders to do this to deliver value for our customers and consumers.

1. Introduction

The *RIIO-2 Sector Specific Consultation* document *(December 2018)* provided a well-articulated and succinct rationale for increased consideration of whole system thinking:

"Energy systems and their networks are becoming increasingly interlinked, amongst themselves and in their impact on the wider economy. The actions of a network company can impact other network companies in the same or other energy sectors, as well as non-energy sectors such as transport. As these linkages grow, so too does the value of coordination across the whole system…There is a growing body of evidence that enabling access to whole system solutions to address these impacts could deliver benefits for consumers, and RIIO-2 can support networks in responding to these challenges"

Whole system has a range of interpretations extending from full consideration of every aspect of energy consumption to additional sectors such as waste, water, transport, and heat – some also including 'behind the meter'.

We believe a broad whole systems definition that considers the possible effects that other closely related energy vectors such as electrification of transport and industry could have on our investment is required. We have a key role to work with industry to deliver on the UK's new legal requirement to reduce CO_2 emissions by 'net zero' on 1990 levels by 2050. As such we are supportive of Ofgem's definition set out in the *RIIO-2 Sector Specific Methodology Decision (May 2019):*

"For RIIO-2 we will adopt a broad definition of whole systems. In addition to the gas and the electricity sectors, the scope of the 'whole system' is expanded to apply to all other areas so long as coordination within those areas produces net benefits for the existing and future consumers of the relevant network sector. For projects involving broader areas, networks should particularly focus on the goals of decarbonisation and sustainable development."

Whole system assessments must identify all potential solutions to a given system issue and determine which option provides the best value for the consumer. We have challenged and reviewed our RIIO-T2 business plan, both load and non-load with the Distribution Network Owners (DNOs) and the Electricity System Operator (ESO), alongside other stakeholders. In several instances this process has found better ways to deliver our plan through coordination and collaborative thinking. As we progress through the T2 period, and customer requirements become more certain, we will continue to work across industry to deliver whole system value for consumers.

In this annex, we focus on three areas:

1. How we have embraced whole systems to date
2. How we have built a whole system business plan submission for the T2 period
3. How the price control could deliver more whole system solutions

Transitioning toward more whole system planning

Over the last four years' energy industry thinking on whole systems has evolved considerably. The Energy System Catapult, through the 'Future Energy System Architecture' report, provided the first substantive review of Whole System thinking. Since then further reports, such as the Ofgem and BEIS 'Smart Systems and Flexibility Plan' have recognised a greater need for whole electricity system planning; and the Electricity Networks Association (ENA) launched the Open Networks Project with several work streams focused on enabling whole systems and the DSO transition. We have positively and comprehensively engaged with each of these reports and initiatives and have been an advocate for greater whole system thinking and planning.

Thinking has recently evolved to consider the practical reforms required to enable the emergence of more whole system opportunities. Four routes have emerged to facilitate:

1. **Enhancing the role of the ESO** – by enhancing the role of the ESO with new incentives, the ESO has proposed new outputs and processes with a whole system focus (*e.g. Network Options Assessment (NOA) Pathfinder projects*)
2. **Licence updates on whole system obligations** – in December 2018 Ofgem launched a consultation on proposed licenced updates stipulating network company obligations in respect of facilitating whole system outcomes
3. **The RIIO-2 Price Control** – the *RIIO-2 Sector Specific Consultation* articulated what the price control could do to facilitate the emergence of more whole system solutions
4. **The Electricity Networks Association Open Networks Project** – the vehicle by which network companies collaborate to develop whole system processes

2. How we have embraced whole systems to date

Coordination across industry to deliver a safe, secure and affordable network is standard practice. We have a long history of coordinating investment planning and delivery with industry. The Grid Code, for example, stipulates the requirement to share data toward developing a coordinated and efficient energy network, and the Security and Quality of Supply Standard (SQSS) and System Operator Transmission Owner Code (STC) set clear boundaries on our engagement for system planning and operations. Additionally, several formal processes and working groups exist, like the Joint Technical Planning Meeting and the Operational Liaison meetings to coordinate outages.

Whole system solutions are also routinely identified through the ESO's annual Network Options Assessment (NOA) process. This whole system assessment compares transmission investment against flexibility services from generators. Our T2 period plan for network reinforcement (set out in *Chapter 7 – Enable the ongoing transition to the energy system of the future*) is built upon the recommendations of the 2018 NOA report, published in January 2019. A further example of whole systems in action is the Connection Infrastructure Optioneering Note (CION). These have been produced by the ESO for most offshore wind and interconnectors in the T1 period. We have actively contributed toward these, providing costs and capabilities of wider network reinforcements which the ESO have optimised alongside developer and constraint costs to arrive at the most economic connection point for these new large connections.

On innovation, we have been coordinating our efforts with all UK electricity transmission and distribution companies through the ENA during the T1 period. Through this forum, we have been able to share lessons learnt and propose projects to promote further collaboration before commencing work and implementation. Over the T1 period the number of parties we have collaborated with for innovation areas has increased, but we recognise that we must do more in this area, and so in the T2 period we will continue to increase the number of parties we engage and collaborate with. This collaboration often provides opportunities for leveraged funding where we are contributing part of the funding towards a project with access to all the learning and outputs from that project.

We agree with Ofgem's hypothesis in the *RIIO-2 Sector Specific Consultation* that blockers do exist that could prevent whole system solutions form emerging. From our experience, we know that much of the sharing of information is weighted toward being procedural (*e.g. as stipulated through network codes*) and the emergence of whole system solutions across the geographic spread of the network can be sporadic and is dependent on the emphasis individual parties place upon searching for these solutions and the extent, and nature of investment they undertake on their networks.

Nevertheless, delivering beyond procedural requirements and creating innovative solutions to benefit consumers is something we've done in the T1 period. Five examples stick out:

1. Working with DNOs to use Automatic Network Management (ANM) as an alternative to network investment to accommodate growth in distributed generation connections
2. Using inter-trips to utilise customer flexibility as an alternative to transmission network works
3. Working with expert bodies to guide and steer our approach to protecting our network and systems from external threats
4. Working with industry and government to develop a strategic network for fast en route Electric Vehicles (EV) charging points across the country
5. Deeside centre for innovation

2.1 Working with DNOs to use Automatic Network Management (ANM) as an alternative to network investment to accommodate growth in distributed generation connections

The growth of decentralised energy connecting to the system has been exponential and is forecast to continue at pace. It presents Reverse Power Flow (RPF) challenges that have required innovative Transmission Owner (TO)-DNO collaboration to resolve.

RPF occurs when the output of distributed generation within a DNO network exceeds the local demand, resulting in the surplus power being exported onto the transmission system via the Super Grid Transformers (SGTs). In some circumstances the level of surplus generation output can exceed the SGT capacity and trigger the need for additional capacity.

To avoid delaying new connections we have been collaborating with DNOs and the ESO, to implement whole system solutions in the form of ANM schemes that adjust the output of distributed generation customers during specific network conditions (*e.g. network outages*).

In the T1 period we worked with DNOs to install 9 ANM schemes for distributed generators connecting as an alternative to spend on SGTs. In total, we estimate that these schemes will reduce costs by between £90m- £108m in avoided SGT upgrades.

In the future, if current policies continue (*i.e. the ability to constrain distributed generation at zero cost*), the use of ANM schemes would continue to provide consumer benefit. However, the volume of distributed generation that can be accommodated behind an ANM scheme is finite. Further, if industry policy changes and distributed generation become eligible for constraint payments (*in the same way as transmission connected customers*), then additional SGTs could be triggered if a cost benefit analysis between the cost of constraints and the cost of SGT investment is undertaken.

2.2 Using inter-trips to utilise customer flexibility as an alternative to transmission network works

The use of inter-trips has long been an option for transmission network companies to manage connections to the network. They differ from ANM solutions, in that they are designed to react to a specific event, whilst an ANM automatically adjusts the active power of the generator in real time based on network conditions.

There are several types of inter-trip, selected depending on the nature of their requirement. Some, but not all, carry commercial remuneration for the customer taken off the network because of the inter-trip operating.

Inter-trips are a good example of whole system solutions in action. They showcase the TO coordinating with customers and the ESO to put in place cheaper commercial non-build solutions to network issues rather than more expensive re-builds or reconductoring.

A relevant example of how we have used inter-tips effectively in the T1 period is as part of the South West Regional Development Plan (RDP). In response to growth in transmission connected and distributed generation, we worked collaboratively with both the local DNO (*Western Power Distribution South West*) and the ESO to develop co-ordinated investment plans that facilitate existing and future generation growth.

As part of this work an inter-trip scheme was developed to prevent circuit overloading during onerous, but rare, network conditions. This scheme will operate in conjunction with the DNO's own ANM schemes in the region and will allow network security to be maintained. The conventional solution would have been to reconductor the existing transmission circuits (*Alverdiscott to Taunton*) to resolve overloads – at a cost of £[redacted]m. The inter-trip scheme can be installed at a much lower cost of £[redacted]m, representing a cost saving of £33m.

Whilst often a solution that reduces overall costs, inter-trips are not always an enduring alternative to transmission network works. As the volume and type of generation changes the need case to build previously shelved solutions may be justified.

2.3 Working with expert bodies to guide and steer our approach to protecting our network and systems from external threats

The whole of society is having to deal with the increased threats from climate change, cyber-attack and terrorism. As a provider of Critical National Infrastructure, we are acutely aware of this. Whilst our network, sites and staff have, to date, avoided harmful events this is not by coincidence. We have made significant effort to protect our networks and this has not been done in isolation.

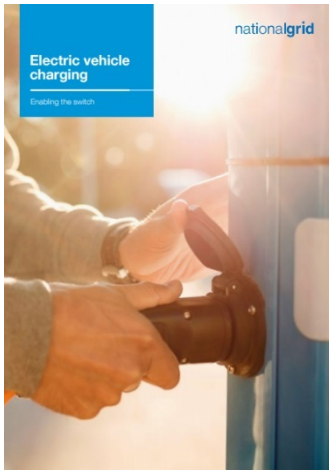
We have worked extensively with other network companies, fellow providers of Critical National Infrastructure and government agencies to guide and steer our approach to protecting our network. Table 1 provides a summary of our engagement with stakeholders, emphasising the collaborative nature to our responsibilities; further details in the chapter on '*Protect the network from external threats*'.

Table 1 – Engagement with stakeholders to protect the network

How we work across industry to ensure a secure network	
Physical Security	We have worked with the Department for Business Energy and Industrial Strategy (BEIS) and the Centre for the Protection of National Infrastructure as part of the physical security upgrade programme to specify standards to be adopted to provide a coordinated level of security
Flood Resilience	We have worked with BEIS and the ENA to define standards to assess flood risk and identify appropriate defences
Cyber Security	We have worked with other utilities, Ofgem and BEIS as a joint Competent Authority to guide and steer a coordinated approach to Network and Information Systems compliance for all Operators of Essential Services
Black Start	We have been working with BIES and wider industry on the Black Start Task Group. This has included developing a new Black Start standard to implement an improved recovery standard for the benefit of electricity network users and end consumers (*details on how this informs T2 investment proposals in section 3 of this annex*)

2.4 Working with industry and government to develop a strategic network for fast en route EV charging across the country

Recognising our role to help to deliver on the UK's legal requirement to reduce CO_2 emissions by 80% on 1990 levels by 2050, and the more stretching target of net zero by 2050 recently adopted by the Government, we are taking an active role in the decarbonisation of transport.



In Chapter 7 of our draft submission and the information leaflet on our website, we emphasise 'range anxiety' as a key blocker to consumers not purchasing an EV. We also propose a strategic network of ultra-rapid EV charge points to enabling a smooth EV uptake for mass market customers.

Given the uncertainty in revenue streams, complex market structures, highly variable site costs and the 5-10-year time horizons of commercial developers, **a market led approach is likely to lead to a patchwork of charging availability and inefficient infrastructure investments**.

As an organisation, **we have pursued an engagement led approach over the last 18 months**, speaking with 133 stakeholders including communities, fellow network companies, consumer bodies and government to address key issues around en route charging. This has focused on three key objectives:

a) Understand and refine market challenges;
b) Test feasibility of high-level solutions and articulate case for private and public action;
c) Co-create delivery options

Chapter 7 of our draft submission and the leaflet, linked above, have further detail on our proposed solution and the whole system approach we are taking. In section 4.2.4.3 of this annex we also provide more detail on our proposals to enable whole system solutions across non-network companies, through anticipatory investment funding mechanisms, to provide options that enable net-zero targets.

2.5 Deeside Centre for Innovation

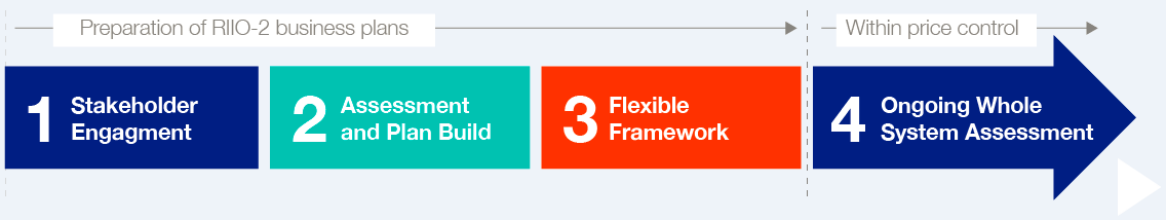
National Grid was successful in securing £12m in funding in 2015 through Ofgem's annual Electricity Network Innovation Competition. This competition allows electricity network companies to compete for funding to develop and demonstrate new technologies, operating and commercial arrangements. Together with an additional £14m from National Grid, we are converting an existing 400kV substation into an evaluation facility where developments and trials of technologies and practices can occur without putting customer supply at risk.

The Deeside facility will be the first in Europe where electricity network assets can be tested off-grid, 24 hours a day, seven days a week. It will provide a controlled test environment and will collect valuable monitoring data throughout its life. We will be running several innovation projects, in phases, over the next four years with gas network companies and the DNOs. More details are included in the next section of this annex on how we have built a whole system business plan.

3. How we have built a whole system business plan submission for the T2 period

We have been working hard in our preparation for the T2 period to build on our whole system work in the T1 period; to find a better way to manage some of the most pressing issues facing the system. Our business plan submission is intertwined with whole system thinking throughout and we highlight several examples in this annex. A whole system submission has been achieved by taking a stakeholder led approach, focusing on the most important issues for our customers and stakeholders. ***Figure 1*** provides a summary of our approach to developing a whole system business plan.

Figure 1 – Whole system approach to developing our business plan



The starting point in preparing our business plan has been our stakeholder engagement. We have gathered considerable insight to inform our plans. In table 2 we provide a summary of what different stakeholders are telling us on whole systems.

Table 2 – What stakeholders have told us on a whole system approach

Stakeholder	What they told us
Distribution Network Operators	• There is an ongoing need for transmission infrastructure at the distribution interface • A national level view of timing of electric vehicle growth and electrification of domestic heating is required • National level scenarios are not appropriate for identifying specific investment requirements at TO-DNO interface – assumptions should be taken directly from DNO data submissions • Rising fault levels could trigger transmission investment in RIIO-T2 • Uncertainty on roles and responsibilities in whole system planning processes identified, particularly following the TO/ ESO split • Important to align asset heath related investment decisions with future customer needs
Electricity System Operator	• More flexibility in executing network outages would help reduce whole system costs • Enhanced capability from existing assets when most needed, while maintaining adequate levels of reliability, would help reduce the whole system costs • Invest in voltage control equipment where required to meet the SQSS Criteria • Invest in system monitoring equipment to allow the network to be operated securely in a world with reducing inertia, lower fault levels and more volatile power flows
Flexibility providers	• The potential for flexibility is sometimes underestimated • There are technical challenges for both flexibility and network companies to overcome • Greater visibility of network issues and their characteristics is needed • Greater acceptance of the services that can be provided is needed • Considerable uncertainty over future opportunities and revenue streams
Customers & cross sector engagement	**Experts and customers told us that:** • An aggregated approach, where the regulated network owner invests in harmonic filtering equipment, could reduce the overall requirement for filters and lower costs for consumers • A change in approach to the charging methodology may be required to accommodate this development • A strategic / anticipatory approach to connecting large volumes of offshore wind on the east coast could accelerate their connection, lower costs for consumers and minimise

	disruption for those communities affected. • range anxiety is a challenge to the Government's ambitions to decarbonise transport **Stakeholders in other sectors and policy makers have told us that:** • Range anxiety is a challenge to the Government's ambitions to decarbonise transport • Existing vehicle charging market structures at Motorway Services are complex and participants do not have enough certainty of affordable infrastructure or utilisation Solutions must be robust to future uncertainty; a whole system approach is required that optimises between transmission and distribution

Using our stakeholder insights, we worked with fellow network companies in a whole system manner to compile a Common Energy Scenario for Great Britain, focussing on key drivers out to 2030. This scenario, which was submitted to Ofgem and the Independent Stakeholder Group, provides a benchmark that will allow easier comparison of business plans. It ensures views on each of the key assumptions in the energy sector out to 2030 for electricity and gas, transmission and distribution are consistent, built from a common platform, and investment is optimised to reduce overall consumer costs.

As part of our input into the Common Energy Scenario work and the development of our draft business plan, we produced our own energy scenario for England and Wales. This scenario was also used to gather stakeholder views in our consultation on managing uncertainty through RIIO-T2 in February 2019.

Our draft business plan is consistent with the Common Energy Scenario. We built the detail of our plan using the stakeholder insights gathered and our energy scenario for England and Wales. In doing so we looked to ensure whole system thinking is built into our plan at all levels. This includes the development of a suite of uncertainty mechanisms that automatically adjust allowances when future requirements, and the party best placed to deliver them, become clearer (see ET.12 *Uncertainty Mechanism annex* for more details). Table 3 summarises relevant examples from our business plan submission. The remainder of this section is devoted to providing more detail for each example.

Table 3 – Whole system examples from our draft business plan

Section	Activity	Example	Submission Chapter
3.1	Low voltage substation re-builds to accommodate higher fault levels from increasing distributed generation.	£105m substation re-build costs removed from our baseline proposals through whole system collaboration with DNOs and development of a new uncertainty mechanism to cover potential future requirements.	Easy to connect and use
3.2	Reactor investments to manage high voltage on the network.	At least £184m of reactor investments not added to baseline proposals by taking a whole system approach and development of a new uncertainty mechanism to cover potential future requirements.	Enable the transition
3.3	Transmission Grid Supply Point as an alternative to distribution network solutions	Working with UK Power Networks (UKPN) to identify the optimal solution for network replacement work in the South East in 2023.	Easy to connect and use
3.4	Asset replacement work in London – London Power Tunnel project	£25m saved through coordinating with UKPN to identify the optimal solution for network replacement work in the London.	Safe and reliable
3.5	Dinorwig-Pentir cable replacement	Coordinating with the ESO to undertake cost benefit analysis to optimise replacement of cable circuits connecting Dinorwig power station.	Safe and reliable
3.6	Ensuring the system operator can operate the system in a zero-carbon future	Coordinate with the ESO and external experts to optimise protection, control and monitoring upgrades to support system operability with higher volumes of decarbonised and decentralised energy connecting to the system.	Enable the transition
3.7	Whole system Innovation	Invest £84m through the Network Innovation Allowance in seven projects which leverage whole system working to deliver consumer benefits.	Be innovative
3.8	Investment to adhere to new black start standard	Invest £20m to ensure our onsite low voltage restoration supplies can meet the requirements of the new standard. Plus, take a whole systems approach to identify need for further dynamic reactive compensation devises to support the network voltage restoration in a black start scenario.	Protect from external threats

3.1 Deferral of low voltage substation re-builds through alternative running arrangements, to accommodate higher fault levels of increasing distributed generation

The growing trend for decentralised generation can present fault level challenges at Grid Supply Points (GSPs) where we retain ownership of lower voltage assets (*e.g. 132kV*).

Fault levels exceeding the rating of substation assets presents a physical safety risk as well as a risk to security of supply. It's a growing issue as the trend for more embedded generation on the system intensifies. Currently we work with DNOs and the ESO to determine if any non-build options can resolve fault level issues. This could include changes to running arrangements in the either the transmission or distribution network. However, the scope to undertake non-build solutions is finite and replacing equipment that has reached its maximum capability with higher rated equipment may increasingly be necessary.

Our analysis identified a potential requirement to invest £105m through RIIO-T2 on low voltage substation re-builds due to higher fault levels associated with distributed generation. This

requirement was included in the first draft of our business plan, which we discussed with DNOs. **Through our collaboration and coordination with the DNOs we have removed these costs completely from our baseline proposals and will develop a new uncertainty mechanism** to cover substation re-build costs we might incur if a transmission investment is later confirmed to be the best solution for consumers (further detail available in NGET_ET.12 *Uncertainty Mechanism annex*).

Removing these investments from our baseline allows us to work with relevant DNOs and the ESO, as more information becomes available, to determine what is needed and who is best to deliver to the overall benefit of consumers. An uncertainty mechanism facilitates this flexibility.

Whilst alternative running arrangements can be effective, they normally represent a move towards a more complex network operating condition and can restrict capacity for further connections and increase future network access costs. If more distributed generation customers connect, the fault levels limits could be exceeded, and investment may be triggered.

3.2 Deferral of reactor investments to allow for the emergence of more whole system solutions to be tested in the T2 period

Keeping network voltage within the statutory limits specified in the SQSS is an important responsibility of network companies and the ESO. Today, the system voltage is managed through both network assets, like reactors and STATCOMs[1] and through services from customers, such as circuit switching (*increasing load to decrease volts*) or through the market, such as paying generators for real power to control reactive power etc.

Voltage on the system is increasing due to reduced reactive power demand (*e.g. less heavy industry and changing domestic technology*), and lower transmission flows, with increasing distributed generation. It's also becoming a harder problem to manage with fewer market participants providing on-request reactive capability.

The ESO has indicated in its Operability Strategy document that it needs access to new sources of reactive power. Our own TO analysis of requirements against the Common Energy Scenario indicates a potential need for approximately 35 reactors across the network in England and Wales ([redacted]).

Ordinarily this would have formed part of our baseline proposals, but through collaboration with the ESO and DNOs **we have reduced our baseline proposals to only [redacted] of the most certain reactors, removing at least £184m of cost, and we are developing a new uncertainty mechanism** to cover potential future requirements (further detail available in NGET_ET.12 *Uncertainty Mechanism annex*). During the T2 period we will work with the ESO to determine what is needed and who is best to deliver to the overall benefit of consumers. An uncertainty mechanism facilitates this flexibility.

For example, we will use the NOA Pathfinder projects to test the suitability of network asset solutions for reactive power against other DNO network solution and commercial options. We will then use an uncertainty mechanism to adjust transmission investment levels.

[1] Static Synchronous Compensator

Further details on our proposed reactor spend can be found in *A7/8.14 – System Operability Engineering Justification Report.*

Regional NOA Pathfinder Projects (Mersey & Pennine)

Through the ENA Open Networks project the ESO has been examining broader opportunities to manage transmission network high voltage issues in the Mersey and Pennine regions of North West England since 2017.

The growth of decentralised generation and falling transmission demand in the region has resulted in the ESO needing to find solutions to absorb reactive power. This is a highly dynamic and localised issue and the requirements are likely to evolve over time.

The ESO is seeking to expand the options to provide voltage management solutions to include the assessment of market-based options against network owner options.

A request for information for solutions in the Mersey region was launched in May 2019 and an equivalent one could be launched for the Pennines in 2020. A competitive tender was launched for Mersey in November 2019, which we are engaging with.

We welcome the NOA Pathfinder projects and are fully engaging with this process as a market participant and will be providing information on the transmission solutions can provide.

3.3 Utilising transmission network solutions as an alternative to distribution network solutions

One of the most intuitive examples of whole system solutions often cited is use of a DNO asset build solution as an alternative to a TO solution, or vice-versa; where it is deemed the other company can provide equivalent (or greater) capability. Finding relevant cases where such solutions are applicable is not always straight forward given the differences in design standards and operating protocols between voltage levels. The NOA Pathfinder projects and the Regional Development Plans (RDPs) are already starting to look at how more of these solutions can be identified.

Our RIIO-T2 draft business plan submission features an example of this type at our forthcoming Little Horsted substation. In the autumn of 2023 we intend to commission a new Grid Supply Point (GSP) on the South Coast of England, at Little Horsted, consisting of two 400/132kV 240MVA SGTs.

The conclusion to build these new transmission assets followed a significant period of working together with UKPN, the relevant DNO, to identify the optimal solution. UKPN are due to demolish the existing 132kV overhead line route connecting Eastbourne and Lewes. The main driver of the project is maintaining security of supply to the Lewes/Newhaven demand group, while addressing deteriorating asset condition and wayleave terminations along several sections of the route. ***Figure 2*** illustrates the Lewes/Newhaven UKPN Demand Group.

Figure 2 – Diagram of the Lewes/ Newhaven UKPN Demand Group

Through extensive collaborative study between National Grid and UKPN several options where considered to replace the existing 132kV overhead line, including replacing the overhead line with underground DNO cables. Two plausible undergrounding options where considered, but both where highly disruptive to local communities. A third option to construct a new GSP at Little Horsted, found through collaborative working was identified as preferable.

3.4 Coordinating asset replacement with UKPN in London

Ensuring we maintain a safe and secure supply to our customers is a top priority for our stakeholders. Replacing assets when they reach end-of-life ensures we can avoid system faults and demand disconnection, and the disruption this causes for customers.

Our asset replacement process, Network Output Measures (NOMs), which is being replaced by the Network Asset Risk Metrics (NARMs) in the T2 period, allows us to identify priority asset replacement. However, we cannot maintain our network in isolation. We recognise our assets were often installed at roughly the same time as DNO assets and their replacement dates can often coincide. We work with DNOs to coordinate and optimise spend, especially for large scale projects.

The London Power Tunnels 2 (LPT2) project is a good example of our coordination in practise. We are working with UKPN, the relevant DNO, to examine viable ways of replace existing TO cable circuits linking East and West London, between New Cross and Wimbledon GSPs. UKPN have interfacing 132kV cable circuits, installed in 1961, also due for replacement and they are also looking to increase diversity of supply and capacity in the region to meet higher South London demand.

By undertaking a coordinated appraisal of asset replacement need and the increased demand, we jointly identified several options and concluded a new 2x240MVA GSP at Bengeworth Road supplied by the New Cross – Wimbledon circuits to be installed in the LPT2 tunnel provides an optimal solution. The tunnel will accommodate the replaced circuits for the TO and the new GSP will serve South London demand, meaning the DNO 132kV cable circuits can be decommissioned. **The incremental cost of a new GSP at Bengeworth Road on our LPT2 project is £[redacted]m, compared to the next cheapest option which was a tunnel share for replacement cables, costing £[redacted]m. This whole system coordination saves £25m**.

3.5 Optimising the Dinorwig- Pentir Cable replacement

Dinorwig, a 1644 MW pumped storage power station in Wales, is vitally important to the GB electricity system. It is heavily utilised by the ESO for frequency control and reserve. Historically holding reserve has cost the ESO up to ~£[redacted] per day, and it is often the single largest loss on the system whilst the power station is pumping to fill the reservoir.

Dinorwig is currently connected to the main integrated transmission system by two single core cable circuits, commissioned in 1980. However, the condition of the cables is deteriorating due to a cycle of thermo-mechanical forces, a consequence of the loading cycles of the power station. This has brought forward the optimal replacement date to 2026 for cable 1, and 2031 for cable 2.

Selecting the optimal replacement solution required coordination with the ESO and ENGIE, Dinorwig's owner, given its importance to system operation and the need to align decommissioning and construction. Our whole system approach to circuit replacement does not have the cheapest capital cost of all the options but does provide the greatest consumer benefit when constraint costs are considered. Multiple options were studied and the preferred option, a three-circuit cable route with the replacement of Dinorwig GSP represented the 'least worst regret' option for consumers. Tables 5 illustrates the results of this study, for the two options taken through to Cost Benefit Analysis with the ESO. Further detail can be found in the associated non-load engineering justification paper (*A9-08- Dinorwig – Pentir Cables*).

Table 4 – Asset replacement options at Dinorwig - Pentir

Option 2	Three circuit cable solution and replacement of Dinorwig Substation. Replacement of all by 2026
Option 3	Two circuit cable solution with substation replacement. Cables replaced by 2026 and substation replaced in 2031

Table 5 - Regret per FES scenario

	Regret[2]				Worst regret
	Steady Progress	Consumer Evolution	Two Degrees	Community Renewables	
Option 2	0	0	0	0	**0**
Option 3	72.26	39.76	61.68	24.84	72.26

[2] Regret is the difference between the option with the lowest Net Present Cost (NPC) and each option by scenario

3.6 Investing to manage the increased challenges of a system transiting to one with significant volumes of renewable generation

The energy system is transitioning to one with increased volumes of non-synchronous generation. In April 2019, the ESO announced its ambition to be able to fully operate the electricity system with zero carbon by 2025.

Fintan Slye, Director of ESO noted "*We will identify the systems, services and products we will need to run a zero-carbon network and design the new competitive marketplaces needed to source these as efficiently as possible, from both new and existing companies. We believe that promoting competition will ultimately lead to better value for consumers*".

We believe that network companies have a vital role to play, alongside traditional 'market' players in ensuring the ESO has the systems, services and products needed. This can only occur however if we have a flexible price control to deliver investment. The uncertainty mechanisms we are proposing (*further detail is available in NGET_ET.12 Uncertainty Mechanism annex*), are a key part of our plans for allowing the ESO to operate carbon free by 2025. They ensure the party best placed to deliver the solution can do so and is able to be funded for doing so.

Operating a system with zero carbon for a transmission owner also means ensuring our protection, control and monitoring systems are robust to meet the challenge of low system inertial and fault levels. Equally the ESO must ensure it has complete visibility of the network through the transmission owner's assets, especially as more of this generation connects away from the transmission system, and behind the meter.

The specific requirements for investing in protection and control systems are still to be indicated by the ESO. However, the transition to higher volumes on non-synchronous generation is already well underway. As such we have been working with the ESO and external experts at Conseil International des Grands Réseaux Électriques (CIGRÉ)[3] and Institute of Electrical and Electronics Engineers (IEEE) to understand the impact on equipment across the network and the mitigation options. Additionally, in T1 we undertook a study with Quanta Technology to estimate the threat and scope of the challenges and lay out a plan for further development to ensure effective operation and coordination of our protection, control and monitoring systems.

To identify the details of the of further investment, it is necessary to develop comprehensive computer programmes to perform the "wider area" protection coordination studies across transmission network with updated generation/system data and accurate models.

We are proposing a baseline allowance of £31.1m in the T2 period to deliver the coordination study and consequential changes to protection settings, including:

Subject to the outcome of co-ordination study, further investment for protection equipment replacement or other equipment installation may also be necessary to maintain protection performance within T2 period and beyond. This cost we propose would be subject to a targeted in period determination.

[3] AKA. The International Council on Large Electric Systems

Alongside protection and control system monitoring is a critical tool in the effort to understand and manage system resilience.

The ESO document, System Operability Framework (SOF) highlights the many concerns including the growing complexity of the system, the need to be able to coordinate operations between the TO and DNO more effectively. System monitoring is the enabler for us and the ESO to characterise the dynamic behaviour in lower voltage networks to an observable level, which can be modelled and used to validate power system studies.

The ESO, has established a new SO-TO code System Performance Monitoring Procedure (STC-P 27-1) which defines the service level it requires from the TOs to provide adequate system visibility and disturbance reporting across their respective sectors of the GB network. The Policy was approved in October 2018 and went into operation February 2019. This requires significant investment and network intervention to be fully in place by the end of T2 period. **To deliver against this requirement we propose to invest £48m of CapEx.**

3.7 Whole system Innovation

Collaboration on innovation provides opportunities to drive whole system outcomes. Over the T1 period the number of parties we are collaborating with on innovation has increased and in the T2 period this will continue and, thus, increase the opportunities for specific whole system solutions to benefit consumers.

We have been listening to our stakeholders on innovation who have told us need we need to be tackling major industry challenges; sharing more data and; be easier to collaborate with, especially for small enterprise companies.

Our seven transformative innovation projects proposed for funding through the Network Innovation Allowance, summarised in table 8 and outlined in the chapter 12 of our submission will all provide whole system benefits focused on providing clean energy and driving down consumer costs. We will engage and collaborate through various mediums to ensure the outcome benefit the whole industry. This will be transparent through the joint monitoring framework we are currently developing with other relevant parties.

Table 6: Proposed Network Innovation Allowance Projects with a whole system focus

NIA Focus Area	Description	Commitments	Cost (£m)
Reducing our carbon Footprint	Reducing our reliance on harmful materials, and finding new materials that are more environmentally friendly	• Investigate alternatives to SF_6 which can be retro-fitted, avoiding the need for costlier asset replacement • Identify methods for reducing or eliminating cement requirements • Implement solutions with novel materials with a lower carbon footprint and which also help with the reduction of visual and environmental impacts Create enhanced methods of measuring SF_6 leakage	£20.4m
Facilitating whole systems energy innovation	The Desside Centre for Innovation is a unique facility that will enable innovation that provides benefits in T1, 2, 3 and	• We will collaborate with other network companies and expand the facility in the T2 period, allowing the facility to be truly whole system and not just for electricity	£20.8m

	beyond. This facility will be available to all networks to benefit the whole energy system, not just our network.	• Include a facility to trial gas (hydrogen and liquefied natural gas) integration, electric transport technologies, and zero-carbon generation technologies • Open the facility to SMEs We will be transparent about the activities at Deeside, to allow all parties to share and collaborate regardless of fuel or network	
Facilitating decarbonisation of wider industries	We know that helping society to decarbonise is the biggest contribution we can make to the environment. We will use our expertise in this area to engage with and support other industries to decarbonise their processes	• Lead the way to a low carbon future by implementing the government's Clean Growth Strategy • Deliver National Grid's role in the transition to electric vehicles • Actively explore opportunities to support and work with other industries (transport, steel, cement) to identify and implement decarbonisation activities • Explore the appetite of other industries to move toward a hydrogen economy and the implications for transmission networks Support industry in the development of technology and systems to help them participate in the future energy market	£12m
Digitisation	The future energy system will interact and be more dynamic than ever before. To respond to these challenges, we want to transform our business through digitalisation.	• Investigate tools and techniques to allow the digitisation of all maintenance, monitoring, and testing of equipment with automated archiving and analysis of information. • Research and investigate algorithms for the mixture of data with various levels of accuracies and time-frames. • Investigate risk in real-time to maximise asset performance and value. • Investigate the potential of artificial intelligence, robotics and research sensors. • Explore how Artificial Intelligence can be applied to our asset, financial and other data sets. Share data across the whole energy system (heat, transport, energy)	£20.4m
More responsive & agile for our customers	Future customers (solar farms, windfarms, industry etc.) want quicker and easier access to the system, to allow them to produce clean energy as efficiently as possible. In the T2 period we will develop tools which allow us to respond to our customers' needs, connect them to the network more quickly and cheaply, and allow us to deliver our future work more efficiently.	• Produce offline tools to replicate our live network, allowing us to respond to customers more quickly Create new assets and installation methods that can be quickly deployed and moved around the UK to support the fast connection of customers.	£7.1m
Addressing Vulnerable Consumers	The initial transition to cleaner energy could have a negative impact on consumers who could be left behind by the transition	• Engage further with stakeholders on our role • Collaborate with parties closer to consumers (suppliers, DNOs, supply chain) • Explore our role in this area with stakeholders (leadership or supporting)	£2.2m

		Collaborate with SMEs to develop further understanding in this area of how we can support vulnerable consumers	
Step change in Health & Safety	The safety of the public, our staff and our stakeholders are our number one priority. Our aim is that there are no injuries resulting from our operations.	Lead research into new safety technology for the whole energy industry	£1.1m
Total			**£84m**

In addition to our Network Innovation Allowance projects focus on whole systems we intend to bring forward whole system projects for the strategic funding pot, replacing the T1 period Network Innovation Competition. These will be summarised as further details on the administration and term of reference of this mechanism emerge.

3.8 Investment to adhere to new black start standard

Planning our response to low probability, high impact events like system wide blackout or brownout events requires deep coordination with stakeholders across industry. In section 2.3 of this annex we highlight our current involvement on the Black Start Task Group (BSTG) and how this is informing the development of a new black start recovery standard.

Through BSTG we anticipate the Secretary of State at the BEIS will move to implement new black start recovery standard in 2020[4]. Working level collaboration between relevant parties currently indicates the new standard will require [redacted]% demand recovery in [redacted]hrs and [redacted]% in [redacted] days, both nationally and regionally. This is the first time that a specific binding standard will be defined in terms of overall timescale required and in the regional application.

To ensure our onsite low voltage restoration supplies can meet the requirements of the new standard we intend to invest a minimum of £20m in non-load related network upgrades, chiefly in on-site power supplies such as batteries and fuel cleansing of small-scale diesel generators. These investments are further described in Chapter 10 – External Threats and Annex A10.08 Black Start Justification Paper. Should the specific terms of the subsequent industry code obligations for the Transmission Owners (TOs) demand an enhanced level of assurance around the confidence of the operation of the assets then further investment in asset capability and resilience, above that covered by the proposed level of investment, may be required.

In addition, initial high-level studies and discussions with the ESO and UKPN have indicated additional investment may be required in the in transmission level dynamic reserve equipment in the network around critical areas of the network, e.g. in London and the South East of England to ensure compliance with the regional element of the standard, should it be implemented. Other areas of the country may also require similar or other types of investment to allow the regional element of the standard to be met. Given the timescales for implementing the standard the exact requirements of additional reactor spend will not be known until mid-2020 at the earliest, once the ESO have introduced the relevant technical code changes required and the resulting network investment implications have been studied jointly by

[4] N.B. The intention to introduce a new standard was outlined in early 2019 and is not a consequence of the Low Frequency Demand Disconnection (LFDD) event following generator trips and frequency excursion on 9th August 2019.

network companies and the ESO. This will be after our final RIIO-T2 submission and therefore any investment will not be included in our baseline proposals.

It is therefore vitally important that an uncertainty mechanism is introduced to give flexibility in the overall level of investment requirement for system restoration and particularly the volume of reactive equipment delivered in the T2 period and ensure standard compliance.

Any investment required will supplement the required level outlined in section 3.2 of this annex.

We will continue to engage with BEIS, Ofgem, the ESO and other members of the BSTG to ensure standard compliance and will provide robust evidence, when available on our exact spend requirements.

4. How the price control can deliver more whole system solutions

Through our engagement with stakeholders in developing our plan, including engagement with Ofgem's consultations, our thinking on how the price control can help deliver more whole system solutions has matured. Throughout we referred to two critical questions:

1. **How can we facilitate more whole system outcomes through existing processes?**
2. **What needs to be addressed in the price control framework to allow for more whole system outcomes?**

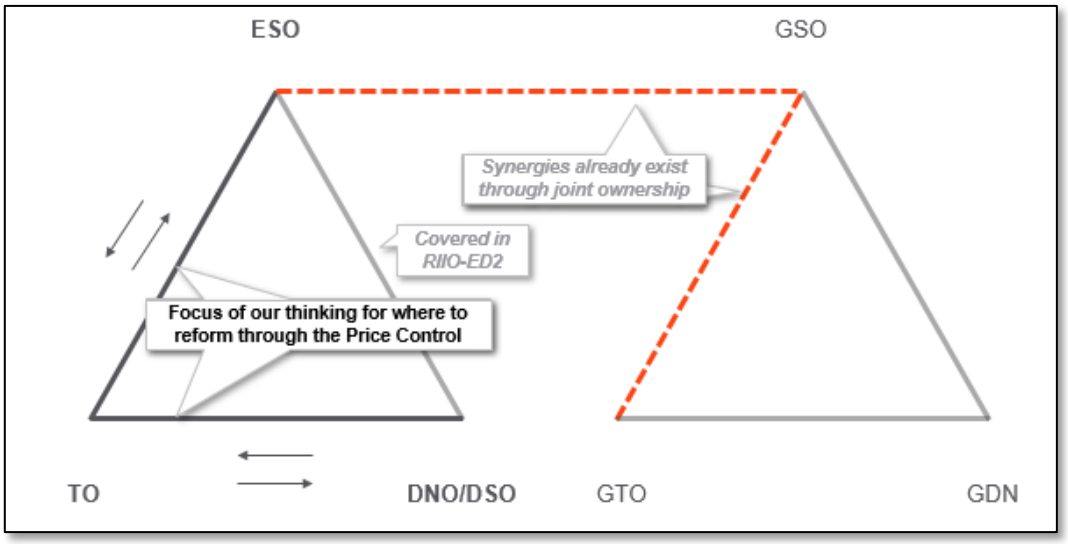
4.1 How can we facilitate more whole system solutions through existing processes?

Thinking through this first question it is helpful to disaggregate the whole systems into two: (*also illustrated in* ***Figure 3***):

1. **Proposals to facilitate better consumer outcomes at the TO-ESO interface**
2. **Proposals to facilitate more collaborative planning at TO-DNO interface**

We believe that there are opportunities to facilitate more whole system solutions across all the industries working to decarbonise the economy. Our relationships with the ESO and the DNOs present the greatest near-term opportunity for us to deliver whole system outcomes in the T2 period.

Figure 3 – Key whole system network company interfaces



4.1.1. Proposals to facilitate better consumer outcomes at the TO-ESO interface

Accountability to operate the electricity system in an economical and efficient manner is the responsibility of the ESO. It uses a broad range of market solutions to do this. Network companies also have a role to help minimise consumer costs. We can provide significant flexibility in the operation of our assets and approach to network outages, when delivering investment and maintenance.

Transmission constraints increased significantly over last 10 years, from relatively modest £[redacted]m in 2008 up to £[redacted]m in 2018/2019[5].(see ***Figure 4***) Increase in cost is mostly driven by the growth in renewables outpacing the growth in transmission capacity between the areas where electricity is generated and where it is consumed.[6]

Figure 4 – Evolution of transmission constraint costs over last 10 years

Currently the balancing mechanism is the main tool available to the ESO in real time to manage network constraints. Analysis of outturn constraint cost **Figure 5** shows that significant proportion of outages affecting system constraint are result of planned outages followed by constraint observed with intact network which indicates TOs flexibility can have significant impact on overall costs faced by consumers.

Figure 5 –*Constraint cost per cause*

As the NOA process demonstrates it is not economically rational or even possible (*because of planned outages etc.*) to design out or mitigate constraint costs to zero. Cost benefit analysis used to determine the optimal level of transmission reinforcement *vs.* the use of balancing mechanism solutions is based on forecast of constraint cost which is highly volatile and very difficult to estimate accurately.

We note Ofgem's latest position outlined in the RIIO-2 Sector Specific Consultation Decision (May 2019), that "*there are multiple existing tools in place to ensure effective collaboration and engagement between the ESO and TOs for the benefit of consumers in relation to constraint costs*." Specifically, the Network Access Plan (NAP[7]), and System Operator -

[5] Constraint cost information taken from ESO System balancing reports
[6] Ofgem-State of the Market 2019 report
[7] Annex A8.04

Transmission Owner Code procedures (STCP) 11.3 and 11.4; OC2 of the Grid Code; and proposed licence updates on whole system obligations for network companies.

We recognise some improvements in the way the ESO-TO relationship is currently managed, however there is a potential for further improvements and efficiencies to be realised and we have identified the three main barriers with existing process:

1. **Uncertainty of cost recovery** - Under current rules TOs can recover actual cost for the service and only when this service is used by ESO. We don't believe STCP-11.3 and STCP-11.4 incentivises the TOs to find truly whole system solutions to benefit consumers. These procedures focus on finding solutions which allow TOs to outperform the TOTEX Incentive Mechanism (TIM), not on finding broader more innovative solutions, with others, which may be in consumers better interests
2. **Cap on use of TOs flexible service** - Under STCP 11-4, utilization of commercial operational Service is limited to £[redacted]m which constrains ability for ESO to procure and for the TO to provide wide range of flexible services. To illustrate this further, if proposed mechanism targets only Main Integrated Transmission System (MITS) outages (*which represent [redacted]% of overall outage number*) this allowance would equate to £[redacted]k per outage which is not enough to unlock full benefits
3. **Administrative burden** - The current STCP defined process for outage change (*including costing and delivery)* is very administrative and involves at least 16 steps with 8 separate interactions between ESO and TOs. We believe that STCP-11.3 and STCP-11.4 are complex and time consuming to administer which mean the time and effort to go through the administrative process discourage its operation.

With that in mind and with expected continuation of decentralisation and decarbonisation trends we believe it's in consumer interest to introduce new tools to manage whole system cost. We have identified the two main areas where further efficiency on ESO/TO interface can be realised:

- ***Optimise system access*** - Introduce a framework tool for the management of system access to provide signals and motivation for TO to minimise the total net costs associated with the agreed outage plan, having regard to its own costs and costs imposed by outages on the ESO and market participants. It can provide motivation for industry participant to optimise its activities and maximise consumer benefit
- ***Getting more out of the existing network*** - Introduce tool to encourage efficient levels of network capability from existing assets when most needed, while maintaining adequate levels of reliability

4.1.1.1 Optimise system Access

Annually there are approximately 9000 outages on the system with only 10-15% of outages are causing network constraint. Looking at the last year performance data we can observe that most constraint costs ([redacted]*% in 2017/18*) are caused by MITS outages, even though they represent only [redacted]% of the overall number of network outages. (see ***Figure 6***). Following the principle of simplicity and proportionality, the optimal approach to capture majority of the benefits from system access optimization is to focus on MITS outages ([redacted]).

Figure 6 –Share of MITS outages in overall number of outages and total constrain costs

As TO, we can provide more flexibility to the ESO in operating the MITS and contribute to reducing total constraint costs. This can be achieved by offering a flexible range of delivery services when we take network outages. For example, rescheduling or accelerating timescales for delivery, providing alternative contracting, maintenance and construction activities, and working practices which otherwise would not be available.

We propose to allow for market-based system for a select number of key outages, the TO will provide a flexible service offering for a competitive rate, which can vary in time to reflect operational considerations. We believe that providing a flexible service offering on transmission outages need not be applied to each outage the TO takes in a year. For example, it could be limited to limited number (e.g. 20-30) of outages a year which cause the highest constraints. These outages can be identified year ahead when agreeing the outage plan and are usually easily identifiable from network studies.

The ESO will conduct portfolio risk analysis across limited range of the outages to balance relatively small option cost risk against performance. e.g. range of outages might be beneficial but only one or two can be called upon. Depending on system and market condition closer to the real time, the ESO can then decide if they wish to request the TO flexibility service given alternative whole system offerings (*e.g. through the balancing mechanism, dispatchable distributed resources, demand side response etc.*). New mechanism will enable parties to keep more options open for a longer allowing to optimise consumer value, make right decision at right time and facilitate efficient performance and effective liaison between the ESO and the TOs for the benefit of consumers.

Through our bilateral engagements with Ofgem and the Independent Stakeholder Group we have provided detailed worked examples of how our proposal could work and the consumer benefits.

In ***Figure 7*** we emphasise the potential consumer benefits and costs from having a flexible outage offering. We highlight if 2018 is examined retrospectively and the top 10 constraint causing outages which represent £[redacted]m (*over* [redacted]%) of total constraint costs are studied, we could have reduced constraint costs by ~[redacted]% (*or £*[redacted]*m*) by having a flexible service position.

We assumed an average cost of TO flexibility is £[redacted]k/day[8] which represents less than [redacted]% of average daily constraint cost for the 10 constraint causing outages and that [redacted]% of constraint cost would be observed even if full TO service is provided.

Figure 7– Potential costs and benefits from a TO flexibility solution

However, we remain convinced that a mechanism is required in this space and advocate a simplification in the way services are procured by the ESO and how the outages are managed. We advocate a system which allows for a more agile, closer to real time use of flexibility with risks allocated to the party best placed to manage it. Our further thinking in this space has identified that a market-based solution would be preferable as it would allocate the risk to the party best placed to manage it – TOs will keep range of flexible options open and ESO will continue to make sure cost of managing system is optimised.

We suggest to consider creating a system which allows the TOs to develop and cost options for the ESO to procure in a more efficient manner.

4.1.1.2 Getting more from existing network

The additional benefits the TO can offer the ESO are not limited to flexible service offerings associated with outages. Being able to offer short-term enhancement of asset capability is also valuable.

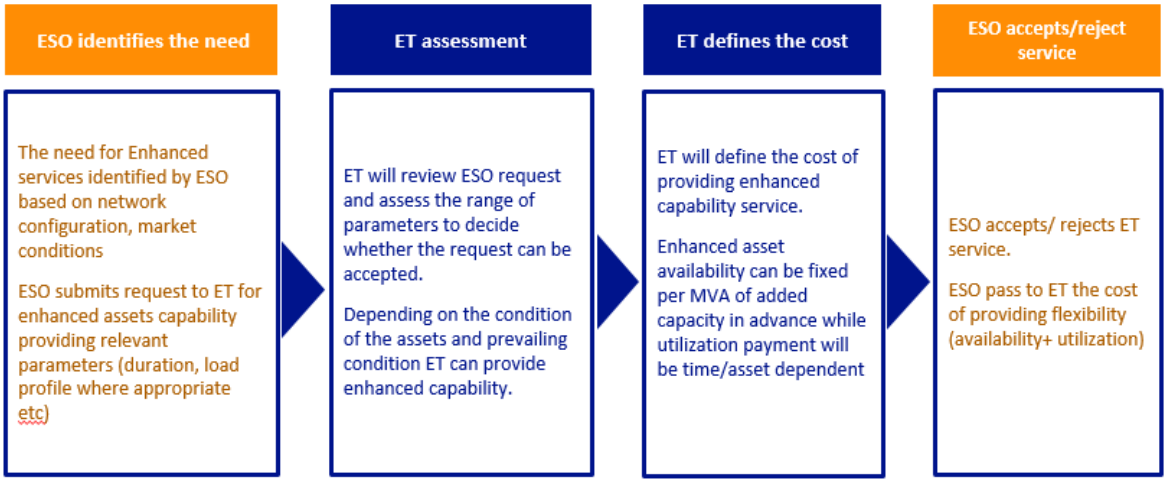
To help manage constraints on the network; the TO can operate the network at an enhanced short-term rating for a limited duration. Providing this service can bring two benefits:

1. Availability (*Pre-fault*) - removing the need for additional pre-fault actions from ESO
2. Utilisation (*Post-fault*) - increased network capability reduces need for short term balancing

[8] Our assumption for cost of TO service provided for illustrative purposes and does not represent our expectation for outturn TO flexibility costs

Identical to our proposed market-based mechanism for flexibility in outage placement we are additionally proposing a market-based approach for TO Excluded Service for providing short term enhancement of asset capability. ***Figure 8*** provides further details on how this could work.

Figure 8– How short-term enhancement of asset capability could work



A critical component illustrated in ***Figure 8*** is determining the cost the ESO pays to the TO for providing flexibility. This we believe should consist of two parts:

1) **Enhanced Asset Availability Price** – this represent monetary value per MVA of additional capability being available (*per day/week/month*) and;
2) **Enhanced Asset Utilization** – this defines the cost if enhanced capability is called upon by ESO

We believe that allowing the TO to commercially offer short term enhancement of asset capability can provide significant consumer savings. To illustrate we retrospectively analysed enhanced rating performance over 3 months (*April-July*)[9] on [redacted] circuits (*currently we provide enhanced ratings for a limited number of circuits that contain overhead lines*).

In these historical cases, we calculated pre and post fault savings from having enhancement circuit capability, by using information about neighbouring line flows and control room post-fault action log sheets. We estimate that taking these actions gave a pre-fault savings of £[redacted]m per quarter (*or £[redacted]k per day*); and if we assume all planned faults happened, potential post-fault savings would be £[redacted]m (*or £[redacted]k per day*, *based on assumption half of the planned trips materialise*).

Given the TO in England and Wales is now legally separated from the ESO, we feel it is prudent that the TO be allowed to recover commercial payment for utilising its assets in such a way in the future. Like other commercial service providers, we can offer flexibility in our assets to benefit consumers, but at present we are not remunerated, given we were not previously legally separated. Creation of such mechanism will enable further innovation and improve competition. We are confident that expanding this service to a wider range of MITS

[9] Analyses conducted prior to ESO separation and while absolute number will depend on exact market and system conditions, we believe the overall materiality is at the right magnitude (if not lower) for conditions expected in RIIO2

circuits can significantly reduce system operation costs, as illustrated in our worked example above.

Both our proposals to facilitate better consumer outcomes at the TO-ESO interface will add significant consumer value. Flexible service offerings associated with outages and short-term enhancement of asset capability both demonstrate the agility transmission network owners can provide. Delivering and operating assets flexibly doesn't come without cost, such as compensating our contractors/supply chain or undertaking more frequent maintenance inspections of assets operating at enhanced ratings. **These are costs the consumer has not paid for in the original funding of the assets.** Under current regulatory rules, TO service will be provided as part of its normal activities but not funded through TNUoS, so it need to be treated as excluded services (or Directly Remunerated Services). This is not a new construct and currently both TOs and DNOs are allowed to set charges for excluded services at a level that allows them to recover their reasonable costs in providing the service with a reasonable margin of profit.

Like our proposals for flexible service offerings associated with outages; our proposals for enhanced asset capabilities should be funded through a market-based approach by reforming STCP-11 to allow for a system which allows the TOs to develop and cost options for the ESO to procure in a more efficient manner.

Our proposals not only provide whole system benefit, they extend competition into non-traditional forms, between network companies and balancing market participants. Giving the ESO a broader range of commercial solutions to manage system constraints greatly benefits consumers.

4.1.2 Proposals to facilitate more collaborative planning at TO-DNO interface

We have articulated the benefit we have already created in the T1 period and built into our T2 period business plan through coordination and collaboration with DNOs. We believe more can be done to encourage the emergence of whole system solutions at the TO-DNO interface.

We contribute to the ENA Open Networks Project, which is developing the processes to facilitate the emergence of more whole system solutions for system planning, including at the TO-DNO interface. Two processes have emerged which can facilitate more whole system solutions: the NOA Pathfinders and RDPs.

We provided an example of how the NOA Pathfinders are helping the ESO find optimal whole system solutions to reactive power issues in the Mersey and Pennines regions, above on page 11. They are also being used to address other regional issues where a DNO or a non-network solution may be preferable to a TO solution, for example constraint alleviation.

The NOA Pathfinders are allowing DNOs and other 3rd parties to propose reinforcement options that can be compared against transmission options. For example, where new capacity requirements are lower, in the order of 100s of MWs, DNOs may be able to offer alternatives potentially in the form of parallel 132kV circuits.

Generally, the consensus opinion with DNOs is that where additional capacity requirements are in the order of 1GW, transmission investment is still highly likely to be most appropriate, as the lower voltage distribution networks would require major upgrades to provide equivalent

capacity, electrical losses would increase and any flexibility service from regional distributed energy resources would typically be insufficient to resolve capacity issues on that scale.

RDPs are collaborative assessments with DNOs to allow consideration of issues that are not covered by the ESO NOA process (*i.e. growth of embedded generation away from the major system boundaries*).

RDPs undertaken with Western Power Distribution (WPD) South West and UKPN are proving to be effective, and the RDP approach is emerging as an effective way to manage local system issues at the TO-DNO interface away from major system boundaries.

The need for a flexible price control framework to work alongside the NOA and RDP processes is also a key requirement to encouraging more whole system solutions to emerge and to be progressed without barriers related to funding.

We believe two of the mechanisms Ofgem have decided to pursue, as per the *RIIO-2 Section Specific Consultation Decision (May 2019)*, the whole system aspect in the innovation package and the Coordinated Adjustment Mechanism will support encouraging the emergence of more whole system solutions. As part of a suite of measures, further incentivisation should encourage the discovery of more whole system solutions.

To be effective and beneficial to consumers, any additional incentive for system planning must be mirrored on all companies. This is a challenge as the setting of RIIO-ED2 lags RIIO-T2 by two years. We are committed to working with Ofgem and wider industry to address this question.

4.2 What needs to be addressed in the price control framework to allow for more whole system outcomes?

We welcome Ofgem's decision in the *RIIO-2 Sector Specific Methodology Decision (May 2019)* on the three mechanisms it will use in RIIO-2 to encourage the emergence of more whole system solutions.

We believe the whole system aspect in the innovation package and the Coordinated Adjustment Mechanism are helpful, but more clarity is required on their specific operation. We look forward to working with Ofgem and industry stakeholders to provide this. In sections 4.2.1 through 4.2.3 we provide a summary of our latest views on the three mechanisms.

On the 27th June 2019, the United Kingdom (UK) signed into legislation a target to reach net-zero emissions greenhouse gases by 2050. An important step to avoid the harmful impacts of climate change. A key component to reach net-zero requires the decarbonisation of our whole energy system at an accelerated rate. In certain areas, a different, more coordinated and agile approach is required to resolve challenges and barriers associated with delivering this, to avoid energy networks becoming a blocker to meeting decarbonisation ambitions. This coordination will inevitably involve a certain level of anticipatory investment.

In section 4.2.4 we outline three potential whole system applications for an anticipatory investment mechanism to enable us to work with non-network companies to provide options to enable net-zero targets.

4.2.1 Business Plan Incentive for whole systems

We welcome Ofgem decision to "*include networks' whole system planning and consideration in our assessment of their Business Plans and the application of any rewards or penalties through the Business Plan Incentive*".

We encourage Ofgem to consider fully the stakeholder led examples outlined in section 3 of this annex 'How we have built a whole system business plan submission for the T2 period'. Additionally, we encourage Ofgem to acknowledge through the Business Plan Incentive our proactive nature in identifying key blockers, going beyond the narrow definition of whole systems originally proposed in the December consultation and providing practical solutions to how existing process and the price control framework can be reformed to encourage the emergence of more whole system outcomes.

4.2.2 Innovation stimulus package and whole systems

We welcome Ofgem decision to "*incorporate a whole system aspect in the innovation stimulus package*". In section 3.8 of this annex we outlined our proposed projects to be funded through the Network Innovation Allowance, a total of £84m of investment, all these projects provide whole system benefits.

In addition to our Network Innovation Allowance projects focus on whole systems we intend to bring forward whole system projects for the strategic funding pot, replacing the T1 period Network Innovation Competition. These will be outlined as further as we work through detail on the administration and term of reference of this mechanism.

4.2.3 Coordinated Adjustment Mechanism

In many cases a central outcome from identifying whole system solutions will be a requirement to transfer either an output or funding between network companies. We believe that the uncertainty mechanisms are the most efficient and simplest vehicle to allow for this exchange. If they are designed to be complementary, and where appropriate mirrored between network companies they will provide an efficient tool to flex the delivery of outputs by a network company, where processes such as the NOA and RDPs have identified new efficiencies compared to the baseline plan. Further, the uncertainty mechanisms can also act as an efficient tool for transferring outputs when network companies have agreed bilaterally to exchange outputs, in the instance another party is better placed to deliver, and the consumer benefits can be demonstrated to Ofgem.

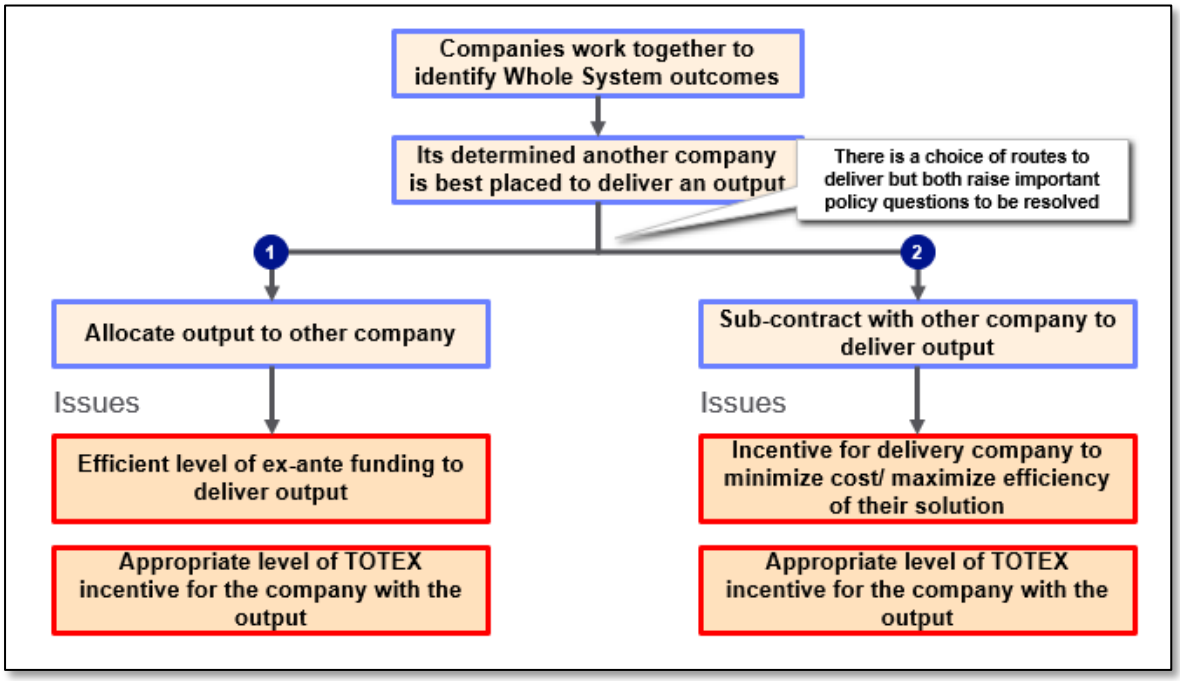
In some instances, however the design of uncertainty mechanisms covering specific assets is not practical or appropriate for some network companies at the outset of a price control, whilst it might be for others. In these cases, an efficient tool is required to allow exchange, so that whole system solutions which benefit consumers can still be facilitated.

We believe Ofgem's proposed Coordinated Adjustment Mechanism is a tool which could address this need. We welcome Ofgem's progress on this and will support to work through the detail of its operation through the draft and final determination stages of the RIIO-2 2021 submission, as well as engaging through the ongoing work that will be required to ensure necessary consistency between sectors, especially electricity distribution.

From our examination of the most recent proposals for the Coordinated Adjustment Mechanism, as outlined in the *RIIO-2 Sector Specific Methodology Decision (May 2019)* we feel many of the salient points that need addressing have been identified, chiefly: (1) the trigger threshold; (2) the timeliness of its use in the price control period; (3) eligible projects; and (4) incentivisation of its use. Important further detail is required on the mechanics of its operation, especially how the outputs will be exchanged between companies.

At present, we have identified two potential routes to one network company delivering a solution for another network company: (1) Allocate the output to the other company; or (2) subcontract with the other company to deliver. Both routes present incentivisation issues that need to be resolved, as summarised in ***Figure 9*** below.

Figure 9 – Approach to reconciling a whole system solution delivered by one network company for another



The Coordinated Adjustment Mechanism is likely to be best suited to route (1), although we note that further detail will be required on how funding levels at the respective companies will be adjusted and the setting of the appropriate level of TotEx incentive for the company with the output. This we feel can be resolved through working through key issues on incentivisation.

4.2.4 Harmonic filtering in period determination

A further implication of operating a system with high volumes of renewable and decentralised generation is ensuring power quality on the system remains within the limits so that consumers receive a stable and dependable voltage supply. **Frequency harmonics** are introduced by new connections through power electronics that are associated with renewable generation and interconnectors.

As the volume of these types of connections increases, so does the requirement for harmonic filters. In preparing our business plan, we looked to understand the opportunity of optimising

harmonic filter placement on the system, given many of the new connections join the main system in similar geographic locations.

By having the network owner optimise and deliver the harmonic filters, rather than customers connecting to the network the total volume of filters required and therefore overall cost can be reduced. Our ongoing stakeholder engagement in this area has been positive to date. For the period up to 2030, a customer led approach would require approximately [redacted] filters to be installed, with a whole life cost of ~£146m. If NGET delivered the filters [redacted] would be required with a whole life cost of ~£119m. We are not proposing any baseline funding associated with delivering harmonic filters, instead once it's been agreed that we are best placed to deliver these we will request the funding through an in-period determination. For the T2 period only we estimate expenditure to be between £60m-£100m.

4.2.5 Anticipatory Investment for whole system solutions to enable net-zero targets

Achieving net-zero by 2050 requires the decarbonisation of our whole energy system at an accelerated rate. A different, more agile and coordinated approach is required to resolve the associated network challenges and minimise cost. Despite T1 period improvements, building the necessary network infrastructure can often take longer than our customers need to deliver their projects. The resulting risk is that energy networks become a blocker to meeting societal decarbonisation ambitions. This more agile approach also needs to ensure it does not place too high a cost and risk on consumers.

We are proposing an Anticipatory Investment mechanism, involving a cross sector group of key stakeholders, policy makers and regulators, that would consider the following factors for key strategic infrastructure solutions to net-zero challenges:

- **Criteria**: define when anticipatory investment is in consumers' interest
- **Need case**: establish what circumstances trigger a pre-agreed investment approach
- **Whole system outcomes**: stakeholder collaboration to ensure optimal, whole system outcomes are delivered
- **Funding**: how companies can recover their efficient costs
- **Risk sharing**: appropriate customer user commitment, consumer protection and reward for value created
- **Monitoring**: provisions to provide regulatory and stakeholder oversight of projects

We will continue to engage with stakeholders to further shape how an ongoing anticipatory investment process could work. Initial results from consumer and stakeholder engagement indicate support for acting early to enable decarbonisation, even if certain solutions are later not fully utilised.

Most stakeholders want us to take a proactive role in enabling the energy system of the future and have challenged us to provide whole system options to address the challenges of net-zero. We've worked extensively with stakeholders to develop the following whole system options:

- East coast offshore wind coordination
- Accelerating EV uptake through ultra-rapid vehicle charging at motorway service areas

These options would be well suited to an anticipatory investment mechanism and further detail on each is provided below.

4.2.4.1 East coast offshore wind coordination

To deliver net-zero by 2050 we may need to safely integrate a further 57GW of renewables by 2025. The cost reductions achieved in both onshore and offshore wind point to a significant role for these technologies in achieving this target. Strike prices as low as £39.65 £/MWh for offshore wind in the recent Contract for Difference round are a strong proof point.

The focus on wind development in the UK has resulted in 18GW of installed capacity over the last 10 years, with an average annual rate of installation of 1.7GW per annum. This rate is dwarfed by the Climate Change Committee's (CCC) stated need for 6-8GW of deployment per annum. Current offshore wind capacity of ~8GW is connected via 32 connections. The same approach to deliver the CCC's target of 75GW 2050 would require an additional 268 connections.

A coordinated approach to connecting offshore wind, supported by anticipatory investment, has the potential to accelerate connections, reduce costs and minimise disruption and visual impact.

A report by Redpoint Energy[10] for Ofgem in 2011 indicated that coordinated investment could reduce costs to consumers by 15%.

The Crown Estate has granted rights to extend existing offshore wind farms by 5.5GW and has proposed around 7GW of Round 4 offshore wind leasing. Most Round 4 sites, approximately 5GW, are likely to connect to the East coast of England.

There is potential for a further 37GW of offshore wind and interconnectors to be developed off the East coast of England in the next 10 to 15 years. These connections imply a high number of cable route corridors, onshore substations, converter stations, and reinforcements to the existing onshore network. To address this challenge, the onshore transmission network could be built around the East coast, reducing the number of circuits required.

This approach, as shown in ***Figure 10*** would expand the existing transmission network on the East coast by building a loop of circuits to shore, providing connection sites for currently contracted offshore wind, interconnector projects and anticipated (Round 4) projects.

[10] A.K.A Baringa Partners LLP

Figure 10: Offshore wind topologies

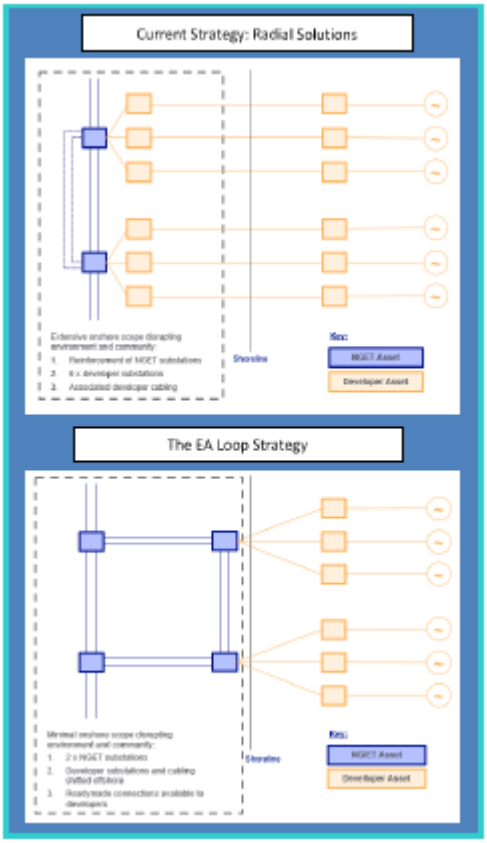


Figure 10 contrasts the current radial approach with a coordinated one that would require less onshore construction, minimising cost and disruption. In current costs, we anticipate that this solution would cost between £3bn and £5bn and deliver considerable net benefits for consumers. Preconstruction work would be required over the T2 period to maximise the benefits this approach, and we propose that any allowances would be allocated as part of the anticipatory process.

4.2.4.2 Accelerating EV uptake through ultra-rapid vehicle charging at motorway service areas

In section 2.4 we outlined how we are working with industry and government, today in the T1 period to develop a strategic network for fast en route EV charging across the country.

To enable EV uptake for mass market customers, a network of ultra-rapid EV charge points will need to be delivered by 2025 – the time at which vehicle cost parity is anticipated. This will ensure that a lack of charging infrastructure is eliminated as a barrier to EV uptake. Infrastructure must allow EV drivers to make long-distance journeys, delivering charging times like those experienced for refuelling existing internal combustion engine vehicles.

While initially these chargers will be underutilised due to the small number of EV users, the most economic infrastructure solution is to plan for a future where there is no liquid fuel. The alternative scenario is to deploy infrastructure after the number of EV users rises, creating an environment of disruptive and costly construction work to modify the network. An inadequate number of charge points may cause queues, leading to a stalled market - reinforcing consumers' perception of range anxiety. Ensuring that there is enough capacity to enable

more ultra-rapid chargers to be added as and when necessary to meet the future demand, ahead of current need, avoids this future expense and disruption to customers.

While some investment has been made into UK charging infrastructure, and approximately 90% of existing Motorway Service Areas (MSAs) have chargers on site, they are usually 50kW chargers which can take over an hour to charge a vehicle. To leverage private investment, the market needs certainty in both affordable cost of infrastructure and EV utilisation rates. We know from talking to prospective market participants that they do not currently have certainty on either, with many struggling to make the case for the costs of the electricity network infrastructure, especially ahead of full utilisation. It is evident that under any likely scenario of EV uptake, due to existing power constraints, most MSAs will require a reinforced power connection before 2030 to meet consumer demand for additional charging points.

TOs and DNOs, together, can enable a smooth and efficient consumer transition to EVs. We have examined the links between the strategic road network and the electricity transmission network in England and Wales to understand the minimal viable infrastructure requirement to overcome consumer range anxiety.

We have studied the power capacity of the MSA sites, across the strategic road network, the journeys EV drivers are likely to take, and how close they would need to be to an ultra-rapid charger to overcome range anxiety. We have also assessed the infrastructure required to support enough ultra-rapid charge points to provide EV drivers confidence and avoid peak-time queues.

As shown in ***Figure 11***, we have identified over 50 ultra-rapid EV charging sites along the strategic road network, where an upgraded electricity network connection would allow 95% of EV drivers in England and Wales to be within 50 miles of an ultra-rapid charging station. This would provide drivers with the ability to charge their vehicle in the time it takes to buy a cup of coffee!

Figure 11: Strategic motorway service areas

We have identified a cost-efficient solution for the sites, which could include a combination of distribution and direct transmission network connections. Of the MSA sites which prove most

economical for a direct transmission connection, 90% could be supplied from existing substations, reducing reinforcement works and minimising the delivery cost.

Policy makers are still considering funding sources for this infrastructure. Anticipatory investment of between £500m and £1,000m in a network of charging infrastructure ahead of full market demand can ensure networks help overcome range anxiety and decarbonise transport a cost-effective manner.