Project Code/Version Number:
SSEEN07 / V2.0

1. Project Summary

1.1. Project Title	Resilience as a Service – RaaS
1.2. Project Explanation	The Resilience as a Service (RaaS) project aims to maintain and improve reliability, particularly for remote and isolated networks, while avoiding carbon intensive standby generation. The project will develop a market-based solution for RaaS to provide customers with a low carbon, cost effective and secure electricity supply.
1.3. Funding licensee:	Scottish Hydro Electric Power Distribution (SHEPD)
1.4. Project description:	1.4.1. The Problem(s) it is exploring In many remote locations, providing and maintaining an acceptable level of network resilience can be expensive, and areas may have to rely on expensive, carbon-intensive standby generation. The bulk of these costs are borne by network customers. The challenge of maintaining acceptable resilience will increase, as we move to meet future carbon targets with the ongoing electrification of both transport and heat, as well as a continued growth in the connection of distributed renewables. 1.4.2. The Method(s) that it will use to solve the Problem(s) For a defined Resilience Zone, a single solution – 'Primary RaaS' - will be demonstrated, connected at HV close to a Primary Substation. This will provide resilience for customers supplied by the Primary Substation in the event of a fault on the 33kV infeed. 1.4.3. The Solution(s) it is looking to reach by applying the Method(s) The Project will accelerate and de-risk the use of services for providing resilience including enabling infrastructure, data exchanges and commercial arrangements, thereby reducing uncertainty for customers and industry. 1.4.4. The Benefit(s) of the project The Project will reduce or defer costly future network reinforcements and the use of carbon intensive standby generation required to maintain a reliable service.

1.5. Funding

1.5.1 NIC Funding Request (£k)	£9,696,262	1.5.2 Network Licensee Compulsory Contribution (£k)	£1,093,110.74
1.5.3 Network Licensee Extra Contribution (£k)		1.5.4 External Funding – excluding from NICs (£k):	
1.5.5. Total Project Costs (£k)	£ 10,931,107.39		
1.6. List of Project Partners, External Funders and Project Supporters (and value of contribution)	Project Partners: Costain, E.ON, SSEN External Funders:		

1.7 Timescale

1.7.1. Project Start Date	January 2020	1.7.2. Project End Date	June 2024

1.8. Project Manager Contact Details

1.8.1. Contact Name & Job Title	Frank Clifton, Development Manager	1.8.2. Email & Telephone Number Fnp.pmo@sse.com	fnp.pmo@sse.com 01738 456414
1.8.3. Contact Address	Scottish and Southern Electricity Networks, Inveralmond House, 200 Dunkeld Road, Perth, PH1 3AQ		

1.9: Cross Sector Projects (only complete this section if your project is a Cross Sector Project, ie involves both the Gas and Electricity NICs).

1.9.1. Funding requested from the [Gas/Electricity] NIC (£k, please state which other competition)	
1.9.2. Please confirm whether or not this [Gas/Electricity] NIC Project could proceed in the absence of funding being awarded for the other Project.	

1.10 Technology Readiness Level (TRL)

1.10.1. TRL at Project Start Date	6	1.10.2. TRL at Project End Date	8

Section 2: Project Description

The Resilience as a Service project (RaaS Project) will reduce or defer costly future network reinforcements and the use of carbon intensive standby generation needed to provide a secure electricity supply, especially in remote and isolated areas. The Project will demonstrate the technical, organisational, procurement and regulatory requirements needed to accelerate RaaS into business as usual operations. To support this, the Project will include development, demonstration and trialling of an economically viable, scalable and replicable technical solution – 'Primary RaaS' - to ensure no stakeholder groups are left behind during the transition to a Low Carbon Economy. Initial analysis by industry experts TNEI, has shown that the solutions being developed will produce over £140M of benefits for GB consumers by 2050.

The Project brings together large-scale project and procurement experts Costain, European energy giant E.ON and the DNO Scottish and Southern Electricity Networks (SSEN). The consortium therefore has the expertise needed to address the complex challenges in developing a strategic, commercially viable RaaS solution.

The Project builds on learning from other projects, especially E.ON's industry leading demonstrator at Simris in Sweden. This seamlessly disconnected ('islanded') a section of E.ON's network from the grid and maintained supply using a combination of renewables, energy storage and smart energy management techniques. The Project will also maintain close links with the NPg Microresilience NIA project, which is investigating an alternative approach to providing resilience at the low voltage connection to the secondary substation. Additionally, the project will develop a strong relationship with the ongoing joint National Grid System Operator and SPEN NIC project – Distributed ReStart.

This project will **Develop** and **Demonstrate** the technical, organisational, procurement and regulatory requirements to accelerate Resilience as a Service into business as usual. The Project will also deliver invaluable insights in developing an innovative commercial approach to the use of Resilience as a Service.

2.1 Aims and Objectives

2.1.1 The Problems which need to be resolved

Key themes and benefits
A robust, reliable and affordable electricity network is needed to meet current and significant future changes to the electricity system. The technical, organisational and commercial arrangements for delivering resilience services at scale across Great Britain, especially in rural areas, will be identified. The Project will address these problems by building upon key initiatives including current and previous NIA-funded projects and E.ON's technical demonstrator at Simris, Sweden.

Providing and maintaining an acceptable level of network resilience can be expensive in remote locations, especially in comparison with more densely populated urban areas. The disruption caused by power outages has a significant impact on stakeholders in these areas. In most cases, security of supply can be maintained using a combination of redundancy and interconnectivity in the electricity network to meet local demand. However, in remote areas it is not always practicable or cost-effective to provide alternative feeding arrangements. Therefore, in these areas, expensive carbon-intensive standby generation is typically deployed, with the majority of costs borne by network customers.

The challenge of maintaining acceptable resilience will increase in coming years as the electricity system evolves. The need to meet future carbon targets will lead to the increased electrification of both the transport and heat sectors, and continued growth in distributed renewable generation. This will lead to a radical change in established electricity demand patterns; low carbon network technologies (LCTs), such as electric vehicles (EVs), heat pumps, and solar PV generation will increase significantly, along with growing volumes of electricity storage. This will drive-up peak network loading, which in turn will increase the investment required to maintain acceptable network resilience. Again, the cost of this will fall on network customers. Therefore, affordably maintaining a robust and reliable and electricity network is key to enabling the continuing development of a low-carbon economy.

To illustrate the scale of the problem, due to the complexity and cost of providing an alternative feed to meet the current ER P2/6, or the future P2/7 standards, SSEN's network has over thirty sections which are supplied via a single source; these adhere to an alternative security of supply standard (EM PO-PS-037). Some geographic locations, such as islands in north and west Scotland, are provided with permanent diesel generating stations; in other areas network security relies on the rapid connection of standby generation in the event of a fault. The majority of these sites also have significant renewable generation connections, which usually suffer disconnection during an outage.

Traditional resilience options such as network investment and diesel-powered generators are costly to own and/or operate and can have a negative environmental impact. However, new technology options are emerging which offer the opportunity to develop new business models for delivering resilience. These approaches could offer increased value for money to consumers and be less harmful to the environment. Enabling technologies include local renewable generation, local energy storage and enhanced network management systems. Resilience solutions have been successfully demonstrated on the international stage, including at Simris in Sweden. Here, E.ON operated a pilot demonstration in which a section of their 10kV network was transitioned from a grid-connected to disconnected ('islanded') mode. The demonstrator used 100% renewables, combined with energy storage and innovative network management techniques to maintain supplies to 150 customers without disruption. Other international demonstrations at industrial facilities such as mines have shown that island networks can operate with high levels of renewable penetration and still maintain adequate resilience. Refer to appendix 4 for further details.

In Great Britain, the integration of these solutions has not been technically proven at scale. Small-scale deployments to-date have been bespoke solutions and are too expensive for widespread adoption. Furthermore, in Great Britain there is no proven commercial model for DNOs to access these resilience services. Also, there is no clear set of requirements to which service providers can respond, or visibility of the resilience needs case in which third parties could invest.

The RaaS Project will demonstrate a method – 'Primary RaaS' - whereby advanced network control is combined with energy storage. During an upstream outage, local renewables and storage will maintain supply without the need for temporary generation, as shown in Figure 1.

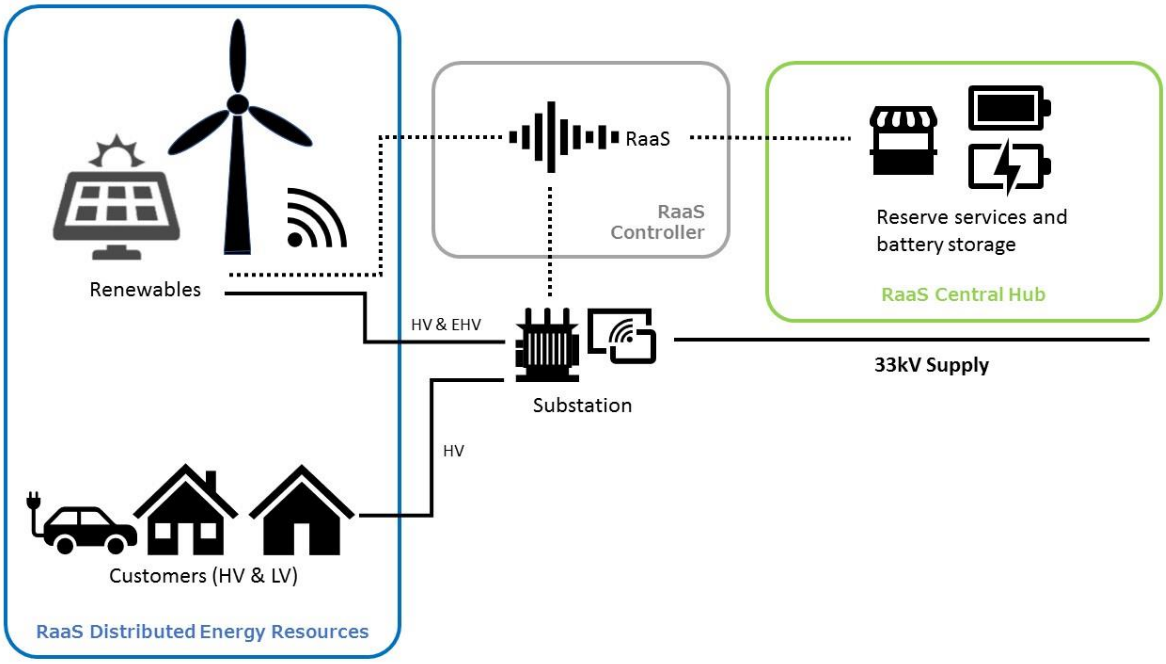

Figure 1: Topology of the Primary RaaS solution. *The RaaS Project will develop a method where advanced network control is combined with energy storage, enabling local renewables to maintain supply during an upstream outage.*

RaaS will develop and demonstrate the technical, organisational and commercial arrangements necessary to create the business model that allows resilience services to be delivered by third party providers to DNOs in a socially acceptable way. In addition, the Project will help generate learning to inform the development of future security of supply standards in GB.

The Commitment to Flexibility

In December 2018, the Energy Networks Association Flexibility Commitment [1] was launched, whereby GB DNOs have committed to include smart flexibility service markets in BAU operations. The Commitment covers projects of significant value commissioned by local electricity operators needing to address congestion in grid infrastructure, resulting from increased electricity demand and/or connection of distributed energy projects. In these cases, local grid operators will test the market to establish what flexibility services are available which use smart technologies such as renewable energy generation, demandside response and energy efficiency measures. The operators will then compare the cost of using such services with building new energy infrastructure e.g. new pylons, transformers and substations.

This approach will create new opportunities for smart energy technologies to compete against and complement traditional forms of energy network infrastructure. DNOs will encourage energy suppliers and other companies to offer aggregated flexibility services by working with households, businesses and electricity generators. In addition, the Open

[1] http://www.energynetworks.org/news/press-releases/2019/june/electricity-flexibilitycommitment-powers-britain-forward-towards-net-zero.html

Networks Project is helping DNOs re-define their roles and responsibilities to enable the new markets for flexibility services.

The RaaS Project is relevant and timely because the business models and learning will develop and extend the flexibility markets approach enshrined in the Flexibility Commitment to include network resilience and security. The Project will also build on the models and outputs from the Open Network project, especially those from Workstream 1A and 1B, which addresses resilience and system security. Finally, the Project will build on the outputs from ongoing NIC projects such as TRANSITION, FUSION and EFFS which are informing the DNO to DSO transition.

2.1.2 The Method being trialled to solve the Problem

Key themes and benefits
The method to be trialled will connect RaaS solutions at high voltage close to primary substations Upon Project completion, GB DSOs will have a validated methodology to identify the best value technology solution for a particular network topology.

For a defined resilience zone, a single RaaS solution will be implemented, connected at high voltage close to a primary substation. This will provide resilience for customers supplied by the primary substation, in the event of a fault on the upstream 33kV network. This method is termed 'Primary Resilience as a Service' (Primary RaaS).

SSEN has a large number of remotely located primary substations which are candidates for a proven RaaS solution. Many of them adhere to an alternative security of supply standard (EM PO-PS-037) due to the prohibitive cost of meeting P2/6. These areas typically have significant volumes of renewable generation connected, which could support local electricity demand during a fault; this is not currently possible due to the difficulty in maintaining stable network operation when disconnected from the grid. The new RaaS service will contain additional network control systems including energy storage equipment to allow the network to run as an islanded microgrid, along with a new contractual framework to allow assets to be utilised in the event of an outage.

Figure 2 shows how the method provides resilience following failure of the primary substation or 33 kV circuit.

Key benefits of the Primary RaaS method include:

- The single (or small number) of standby resources reduces complexity in design and operation, and may lower cost; and
- The RaaS service provider and third-party owner of assets can 'stack' revenues from other opportunities within the electricity market, such as grid balancing markets. This means a stronger business case for the service provider, and lower cost RaaS for the DSO.

In summary, developing methods for delivering Primary RaaS provides more resilience options for DNOs. The Project will also provide a validated methodology that DNOs can use to identify the best value option, in terms of benefits and costs, for a particular situation.

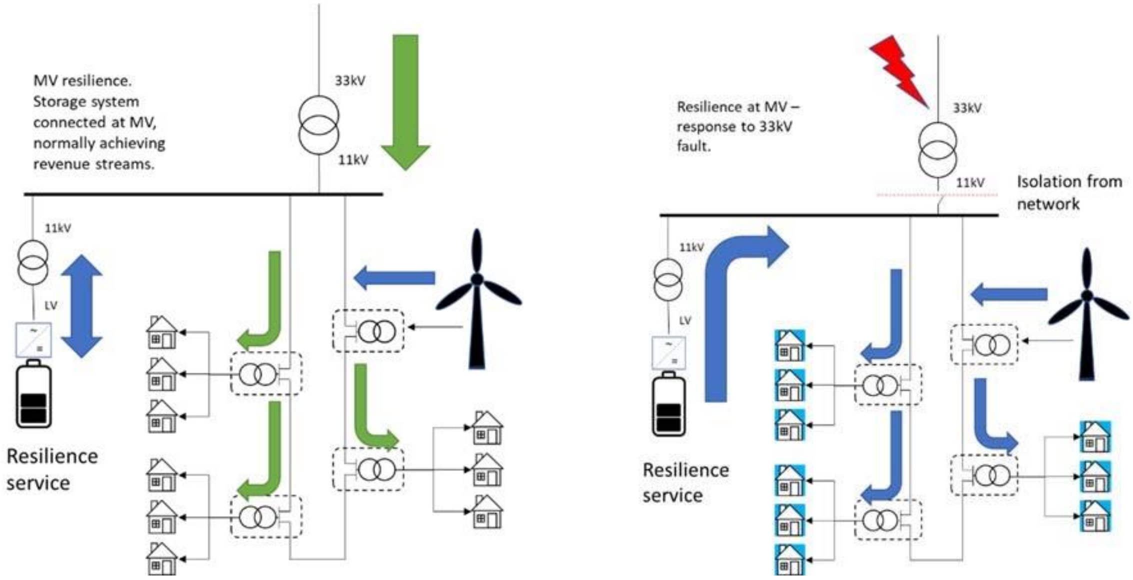

Figure 2: Principal failure mode for Primary RaaS (single RaaS solution deployed close to a primary substation). *The primary substation or 33kV network fails, so RaaS intervenes to keep the connected 11kV assets live (blue).*

2.1.3 The Development and Demonstration being undertaken

Key themes and benefits
The Project will develop the solution requirements for future market participants. This will provide them with the clarity and certainty they need to compete effectively in the new RaaS market. The Project will also demonstrate the Primary RaaS method on an SSEN network.

The Project will carry out trials to demonstrate Primary RaaS, and will determine solution requirements for potential market participants, that is, parties involved in providing RaaS. To test and exploit the value of the demonstrator, we will run a parallel exercise to the technical demonstration, testing the commercial arrangements with potential market participants such as requirement specifications, information flow and commercial arrangement. The intent of this is to maximise the learning from the investment in the Project while acceptance-testing the RaaS commercial arrangements with its future participants. In addition to the technical development, the project will also consider, how best to:

- Develop roles and responsibilities for market participants (MPs);
- Develop market rules to allow market participants to transact services effectively;
- Clarify RaaS requirements from both a DNO and potential service provider perspective;
- Engage and consult stakeholders across the industry; to ensure a scalable market design that has buy-in from all potential parts of the RaaS value chain;
- Identify network locations on which to trial use cases; and Provide feedback on the learnings from all of the above.

Key activities are further discussed as follows.

Roles and responsibilities must be defined to provide clarity and certainty for all market participants, so they can participate effectively in RaaS, and they will be subject to stakeholder review as part of the Project. The market rules will be developed to ensure a fair, competitive, and transparent marketplace and enable market participants to efficiently engage in RaaS service transactions. The **market rules** will address the following areas:

- Allocation of the RaaS roles and responsibilities between DNOs and other MPs;
- Optimisation of the RaaS technical parameters, such storage size, to allow service delivery into other markets in addition to resilience provision;
- Optimising availability – the requirement for RaaS will vary throughout the year and both commercial and technical aspects of RaaS need to support this;
- Definition and valuation of additional revenue streams for technologies used primarily to provide resilience, to allow for potential revenue stacking by MPs to reduce overall costs for network customers;
- Ensuring the length of contracts, method of tendering/competition and assessment criteria are technology and supplier and technology-neutral;
- Identifying risks of conflict between market participants, when providing services;
- Working within network constraints, that may limit the ability of RaaS resources to fully access other wider revenue streams;
- Managing transactions that have potential to adversely affect the network or create unintended consequences;
- Inform technical definition of RaaS interfaces through protocols and standards; and
- Clarification of RaaS technical and commercial service requirements from the perspectives of DNOs and potential service providers.

The success of the Project will be highly dependent on effective **stakeholder engagement**. This will secure the detailed views of customers, service providers, equipment suppliers, aggregators, other licensees and other potential market participants – the project aims to create the conditions for the RaaS market to scale with many MPs, and NOT to deliver a small number of demonstrations and limited market participation. Success will ensure the RaaS market is fit for purpose from a whole system perspective and provide a wide range of feedback to the Open Networks Project – the industry-wide project to help the industry transition to a smart grid[2].

In summary, the Project will develop a meaningful set of solution requirements, and clarify market roles and responsibilities, rules and models under a variety of use cases.

2.1.4 The Solution which will be enabled by solving the Problem

Key themes and benefits
This project will demonstrate resilience as a service for rural networks in a GB context for the first time, de-risking the integration of new techniques for networks to 'keep the

[2] http://www.energynetworks.org/electricity/futures/open-networks-project/

lights on' for these customer groups. Furthermore, it will develop the business models for DNOs to procure this "as a Service" from a third-party provider. The project will pilot the commercial model as a first-of-a-kind, and then use the lessons learned to stimulate wider market engagement in RaaS provision, creating confidence in DNOs, RaaS providers and other parts of the industry to scale the market rapidly.

The RaaS Project will aim to demonstrate resilience technology in a GB context, how it can be used, and how a competitive RaaS market can be established for all GB DNOs.

Furthermore, the Project will provide solutions to the many and important non-technical aspects of RaaS – that is to say, the project will create a well-defined and detailed business model approach all GB DNOs can use consistently, which in turn will provide confidence to the potential RaaS providers and investors, resulting in a faster BAU adoption of the solution.

In addition to substantial work on business models and industry engagement, the RaaS project will provide solutions for DNOs to:

- Understand the costs and technical performance of providing resilience at Primary scale, compared with the Distributed Options being tested in NPg's Microresilience NIA project;
- Understand the risks of providing resilience using these solutions , and therefore inform how RaaS should be structured and procured to ensure risks are appropriately allocated, to produce the best overall outcome for electricity consumers;
- Articulate RaaS requirements to the RaaS provider market, in terms of both commercial agreements and technical operation;
- Understand other market participant views on RaaS, ensuring that the RaaS market considers the needs of potential RaaS providers;
- Create transparency in the market about RaaS in terms of how requirements are defined, and how RaaS tenders are evaluated;
- Standardise data that needs to be exchanged for the procurement and operation of RaaS;
- Obtain clarity on the potential size of the RaaS market, creating supplier and investor confidence about the scalability of the market; and
- Define any changes to market rules and codes, such as system planning standards, to enable RaaS to be deployed and compete with traditional approaches to providing resilience.

In summary, by providing solutions in technical and non-technical areas, the Project will create confidence in both the GB DNO and RaaS provider communities about how the market will operate, and where different RaaS solutions are optimal. This confidence will lead to reduced perception of risk in novel resilience solutions by the industry and enable rapid acceleration of the RaaS market as an alternative to traditional network investment.

2.2. Technical description of Project

Key themes and benefits

The Project will build on SSEN's experience maintaining electricity supply in remote locations and the incremental learning from three earlier NIA projects. The Project will trial the 'Primary Resilience as a Service' method, whereby a RaaS solution is installed adjacent to a 33kV primary sub-station and thereafter maintains the lower voltage (11kV) network.

There are a number of international examples where the combination of energy storage and distributed generation combined with intelligent network management has been used to maintain network integrity. Examples are presented in appendix 4. Historically, SSEN has maintained supplies to remote locations such as the Western Isles in Scotland using embedded diesel generation. SSEN therefore has significant experience of the technical issues, particularly the impact of distributed generation.

This Project is also informed by work undertaken by SSEN in three previous NIA projects: NIA_SSEPD_0012(4), NIA_SSEPD_0013(5) and NIA_SSEPD_0019(6). All of these have studied the use of embedded assets and standby generators to improve network resilience in small sections of the network.

This Project will allow the concept to be developed, testing to be accelerated and the solution implemented on the network. The learning and knowledge gained from the Project will resolve many potential technical and commercial issues to give DNOs the confidence to implement the solution. This will be impossible without NIC support, as the development cost, risk and likely delays, new risks and third party reliance are incompatible with business as usual projects.

The Project demonstrator will provide confidence that the RaaS System connected close to a 33kV primary sub-station, can energise and maintain the downstream 11kV network in a stable manner, in the event of an upstream fault.

A full description of the work packages and key tasks of the project is included in Section 6 and appendix 3.

2.3 Description of design of trials

Key themes and benefits
The Project trial on SSEN's network will follow the approach used in E.ON's successful demonstrator at Simris in Sweden. A local black-start response to unplanned outages will be employed, with all technical and commercial challenges addressed. Detailed technical specifications will be developed for system elements such as a battery energy storage system (BESS), a DNO control room data interface, and an energy management system (if selected). The trial will also identify BESS whole life costs, and the optimum approach to managing the various service demands on the BESS.

2.3.1 Primary resilience on the network

The trial methods, technologies and physical architecture of the medium voltage RaaS demonstrations on the SSEN network are expected to follow the microgrid demonstration at Simris, Sweden. In addition, we will focus on optimising resilience against unplanned outages whilst facilitating opportunities for RaaS providers to generate additional revenues from other markets, which will reduce the overall cost for network customers.

A Battery Energy Storage System (BESS) is expected to be the primary storage technology to act as the voltage source needed to provide resilience and will be connected to the SSEN network at 11kV. This will be combined with appropriate energy management systems, to manage power flows and network stability, and include integration of locally connected renewables. Factors affecting the BESS technical specification include requirements for network power, resiliency duration, available capacity at the point of network and access to additional revenue streams to provide other resilience services. A headline BESS specification of around 3MW/3MWh is proposed for the trial, which will cover over 90% of three-hour duration outages. The trials will be structured to allow a range of fault and network scenarios to be demonstrated and / or simulated.

The detailed design objectives will be agreed during the first phase of the RaaS project, which will shape RaaS functionality. The simplest approach for long outages is to allow a short network outage (10 seconds) whilst the section of network is isolated from the grid, then effect a black-start using the RaaS equipment. This approach impacts the BESS specification, which must be able to run in two distinct modes each with different earthing arrangements i.e. as a controlled real and reactive power source when grid-connected, and as a voltage source when islanded. As the BESS is expected to comprise several discrete but co-ordinated battery systems, controlled power sharing between the BESS systems will be specified.

From a network operation perspective, an approach to the safety case, dynamic earthing arrangement and response to failure will be agreed and documented, in a manner similar to the demonstrator at Simris. The BESS is expected to deliver defined, although significantly lower, fault current than the grid connection, and dynamic protection settings for the BESS will be agreed with SSEN. This will result in an electric current and duration requirement for the BESS, potentially along with a requirement to change settings for protection relays with two distinct settings. Again, this will be determined during the detailed design work in the first phase of the Project and will build and further progress the technical requirement being developed in the Distributed ReStart project.

The simplest approach to local black-starting the network following an outage would be to demand full voltage and allow the BESS electronics to operate against the current limit. However, this must be coordinated with the protection scheme so that the system does not 'trip' because of an over-current or under-voltage during energisation.

The optimum physical location for the BESS is at the primary substation. This will allow direct hard-wired communication between the BESS and the circuit breaker whilst avoiding the expensive trenching needed to deploy new fibre-optic cables. The BESS will interface at 11kV, and the scope of supply for the medium voltage transformer will be agreed.

The interface requirements to the DNO control room (potentially through an ANM supplier) and any other market participants will then be defined, along with the data that needs to be communicated. After the control functions and interface requirements are understood, a decision will be made on the division of scope of supply for the control system i.e. whether an independent energy management system is required, or whether the BESS supplier can integrate the functions into its local controller.

Trial objectives and methods

The trials on the SSEN network will assess both technical and commercial issues in providing resilience. The commercial aspect includes developing an understanding of the cost and implications of delivering, installing and operating the RaaS system, balancing the conflicting requirements of using the BESS energy for resilience and maintaining sufficient energy for resilience when needed. The technical demonstration should include disconnecting the section of network from the grid and verifying that the RaaS system can:

- Detect the outage;
- Take all necessary actions autonomously to restore power to the islanded network in a controlled and safe manner;
- Operate the 11kV network in a stable way, combining BESS with any renewable generation in the network for a defined period including returning the network to normal operating mode ; and
- Effectively communicate system status to the SSEN control room.

During islanded operation, the system fault response will be tested to ensure stability and safety. The duration of the islanded operation will be at least two hours, with the potential to extend if practicable. Upon return of the network voltage, the RaaS system will:

- Detect the supply has returned;
- Take the required action to restore the network connection in a controlled manner; and
- Return control for operation in other commercial markets.
- Consolidate all commercial aspects of the event.

2.4. Changes since Initial Screening Process (ISP)

The ISP was originally submitted as a collaborative project with SSEN and Northern Powergrid (NPg). SSEN were leading the development of the Primary Substation RaaS described above, which is a progression of the approach successfully demonstrated by E.ON in Sweden. NPg wanted to develop the learning from their ongoing Microresilience NIA project. However, it became apparent the concepts being developed in that project will not be sufficiently developed to support a submission to this year's competition. However, NPg will retain a place on the Project Steering Board to ensure that the learning from the Microresilience project informs the development of the RaaS solution. This will be particularly important during the preparation for the Stage Gate. Depending on the progress of the NIA project, NPg may submit the Microresilience project to a future NIC.

In preparing the Final Submission, the partners have better defined a detailed Project scope and programme. This has resulted in an extension to the project end date from December 2023 to June 2024, and a reduction in the funding request from **£15,000,000** to **£9,696,262**.

Section 3: Project business case

Key themes and benefits
The Project has a strong strategic fit with the changes Network Licensees want to make to their business over the next decade. This is because RaaS will help ensure the new DSO model delivers benefits that are shared by all customers, particularly in remote areas. RaaS benefits will pay back the cost of funding the project after only 7 deployments. RaaS will also enhance resilience provider revenues and build the business case for distributed energy resources in rural areas. Innovation funding is needed to address the many technical and commercial challenges before the solution can be rolled out at scale however on a successful conclusion we anticipate the early replication of a fully tested RaaS commencial and technical solution.

Strategic fit

SSEN are proactively engaging with the ongoing energy transition through a number of long-term strategic goals and activities, including:

1. Following our strategy for transitioning to a DSO (Our Transition to DSO[3]);
2. Collaborating with other DNOs through the Open Networks Initiative (Open Networks Workstream 3 DSO Transition[4]); and
3. Building upon business plan commitments that have already been made (Annual Business Plan Commitments[5]).

SSEN is committed to improving resilience of remote and rural areas of the network. These networks have traditionally been more likely to experience higher levels of interruption, due to the high cost of providing network redundancy in these locations. We expect these customers to have more reliance on electricity in the future due to the widespread electrification of heat and transport, similar to other GB networks. A lack of public transport in these areas, the large geographical area covered by any single fault and seasonal tourism patterns may further increase the impact of decarbonisation on demand and electricity reliance. In addition, customers in rural and remote areas are more likely to suffer from fuel poverty. SSEN is fully committed to ensuring that vulnerable customers will benefit from the DSO transition. RaaS supports an evolution to a more reliable and economic electricity network, decarbonisation of the energy system and the transition to DSO. Crucially, it will help to ensure that benefits from energy system changes can be **shared equitably by all customers and recycling investment back into local communities while**, focussing on customers in more remote areas who have traditionally had a less reliable electricity supply and who may suffer from greater energy poverty.

Ensuring a reliable supply of electricity
"We will reduce the small number of customers that suffer more than 3 unplanned supply interruptions per year by 30%" (business plan commitment)[5]

Since 2012/13 we have seen an overall improvement in unplanned supply interruptions performance across the SHEPD and SEPD areas. However, there continue to be "hotspots" which experience worse than average frequencies and durations of outages. These are often in rural and remote areas or islands, where providing traditional network capacity can be technically and financially challenging. **RAAS will directly target these hot-spots to improve electricity reliability to these areas.**

DSO Priorities and Principles

[3] https://www.ssen.co.uk/SmarterElectricity/
[4] http://www.energynetworks.org/electricity/futures/open-networks-project/opennetworks-project-workstream-products.html/ws3-dso-transistion.html
[5] SSEN, Annual Business Plan Commitment Report 2017/18

SSEN[6] has published their views on the steps towards t**he DSO transition. SSEN's strategy describes the following priorities and principles.**

Principle 1: A DSO must work for all customers. We want greater choice and opportunity for customers, whilst ensuring the service we provide remains reliable, efficient and resilient, particularly for vulnerable customers.

The DSO transition should enable network reliability to be maintained and improved for all customers including those in remote and rural locations and those who suffer from fuel poverty. These customers should also have access to greater choice and opportunity in a more market-based framework, with an approach that is suitable for low customer density and network topology. **The transition to a DSO** provides a chance to improve choice and opportunity for these more **vulnerable customers. RAAS will accelerate the market and technology needed to facilitate the DSO transition at the remote fringes of the network in an efficient way.**

Principle 2: Learning by doing will give the best outcomes for customers. SSEN has a wide portfolio of innovation projects that test the credentials of new technologies and solutions with respect to de-carbonisation, resilience and affordability. The best outcomes for customers will be realised through listening to their needs, practical evaluation and scaling up success.

SSEN is strongly committed to learning by doing for the DSO Transition through delivery of innovation projects such as its NIC funded TRANSITION**.** "System Defence and Restoration" has also been identified as a DNO function[7] in the Open Networks project, with research activities including the design and operation of resilience schemes and of "islanding" arrangements. **Whilst this shows the commitment of industry to understanding new approaches for resilience, a demonstration project will be able to more fully derisk this approach. RAAS will support this learn-by-doing philosophy to develop and demonstrate a novel, complete and untested approach for improving network resilience. This will improve reliability for the networks worst-served customers.**

Principle 3: Our transition to DSO must be coordinated and cost efficient. We will use our experience to focus on ensuring that the total costs charged to our customers are fair and proportionate to the benefits, all the while listening to their short and long-term needs.

DSO Priorities and Principles

Remote and rural areas have experienced poorer network reliability due to the high costs and technical challenges in providing network redundancy. This will be exacerbated as network loading increases due to decarbonisation. A DSO transition should enable more cost-effective and low carbon solutions to be available for improving network resilience compared to traditional, costly reinforcement. **RAAS will ensure that resilience of supply in rural and remote areas can be provided in a fairer and more cost-effective way.**

[6] https://www.ssen.co.uk/SmarterElectricity/
[7] http://www.energynetworks.org/assets/files/ON-WS3-P2%20DSO%20Functional%20Requirements.pdf

RaaS has significant *potential* benefits for customers, particularly worst-served customers

The RaaS project has the potential to deliver net financial and carbon benefits for GB consumers and could potentially deliver significant benefits for the networks worst-served customers. We have explored the scale of these benefits in a cost benefit analysis (CBA) model, which identifies the cost of providing resilience through RaaS and through various other means for 114 candidate sites. The CBA calculates that RaaS has the potential to deliver £147m of financial benefits for network customers by providing improved resilience at a lower cost for 111 of these sites. Separately, we have identified that the methods would deliver potential benefits of up to 16.6kT of avoided CO_2 equivalent, based on removing the need for diesel generation, and the avoided embodied carbon of reinforcement.

The underlying assumption for the CBA is that electrification of heat and transport will increase customers dependence on their electrical supply. Therefore, the historical levels of interruption experienced by remote and rural customers (in terms of minutes lost) and absence of locally accessible alternative supplies will be unacceptable in the future, meaning DNOs will have to intervene in order to improve resilience. This is also one of our priorities in the DSO transition. Alongside RaaS, there are two counterfactual options for improving resilience, each of which has different challenges. **Figure 3** shows RaaS alongside the counterfactual approaches:

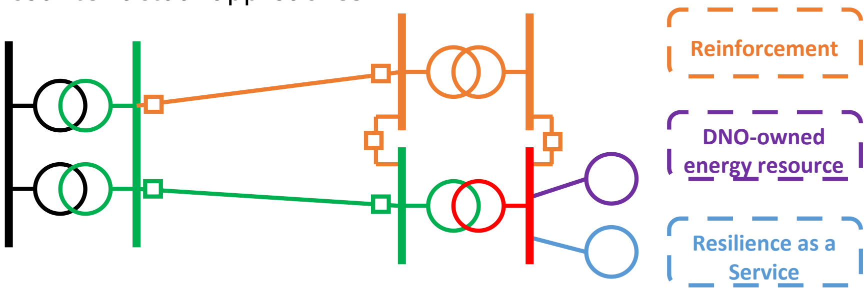

Figure 3: Three options for improving resilience.

- **Reinforcement:** this includes a new transformer and an additional redundant circuit. The types of sites we are considering for RaaS tend to be the most challenging for traditional reinforcement costs due to factors like distance, access, space, ground conditions etc, which we have reflected in the CBA. In addition, these types of rural areas are often the most sensitive to the visual impacts of new overhead lines, which means gaining planning consents can be very challenging and often add significant delay. We have reflected this in the CBA by assuming that, for these sites, a proportion of the route would have to be constructed using underground cable.
- **DNO owned energy resources:** a cheap option for improving resilience is to have standby diesel generators at (or near) the substation, which can then be run when the network connection is interrupted. However, these have significant detrimental environmental impacts, including CO_2 emissions and impacts on air quality. They also need to be run regularly to keep them maintained and fuel needs to be available on site. In addition, the continued use of diesel is unlikely to be viable, for example it has been recommended that new diesel vehicles should be banned from 2032 onwards. We have therefore allowed diesel generators to provide resilience in the counterfactual, but only until 2028 (i.e. during RIIO-ED2). After 2028, we assume that in this counterfactual, DNOs would utilise batteries to provide

resilience. However, DNOs will be unable to use owned batteries to access any other revenue streams and therefore these batteries are only being used for resilience. This means that, in this counterfactual, the entire cost of the DNO-owned battery is associated only with providing resilience.

Therefore, RaaS has a clear role to play when considering the environmental and economic challenges associated with other means of providing resilience.

These benefits would be realised by GB energy consumers through a reduction in the DNO's allowed revenue, passed through as a reduction in Distribution Use of System charges. Although CIs and CMLs will reduce with RaaS, we have not considered these benefits explicitly in calculation of the financial benefits.

After factoring in the costs of the project, the CBA shows that these benefits would pay off the cost to the consumer of funding the project after only seven deployments, compared to the 111 that we have identified within the CBA. This CBA is discussed in more detail in Section 4 and Appendices 1 and 2.

RaaS will help to build the business case for distributed energy resources in rural areas

From a technical point of view, providing resilience with RaaS would be similar to a DNO owning and operating a battery. However, the commercial framework would be market based, with a third-party service provider owning and operating the battery and the associated ancillary equipment, with the DNO paying them a service fee to make it available to provide resilience.

Therefore, RaaS will help build a business case for DER in rural areas through providing a further revenue stream that wouldn't be available in more central locations. This could help to further encourage the connection of other renewable generators and DERs in these areas, helping to make the entire local energy system more efficient. In time, this would potentially help to facilitate other innovative technologies in these areas, such as Vehicle to Grid, which may not otherwise have a route to market.

During interruptions, it will be in a service provider's own interest to help to maintain supplies in the local network. This is in contrast to other flexibility services which might require providers to curtail their own import or export, or to hold capacity in reserve to respond to faults.

There are good reasons why the RaaS service could be relatively cost effective:

- **Stacking:** The provider will be able to access revenues from a (potentially) wide range of other services, such as frequency response, capacity, imbalance, arbitrage etc, and the cost of the battery will be shared between RaaS and all of these other services. This means that the cost of the RaaS service, in principle, only needs to pay a premium to the service provider in order to (i) motivate them to locate their battery in a RaaS site, rather than a more central location, and (ii) cover any potential loss of revenue during periods of interruption. We will explore conflicts and synergies of services in more detail in the project.
- **Contract length**: We've carried out the CBA with an assumed five-year RaaS contract, which is longer than many existing service contracts, assuming a 6-hour battery is needed to protect against a majority of 12-hour outages. Batteries asset life is typically longer than this, with lives of 10-15 years common. A competitive

provider wouldn't necessarily look to recover all of their battery cost through a single contract period, as they might allow for some residual value at the end of the contract (particularly if one of their service buyers, e.g. the DNO) has signalled that there are likely to be ongoing requirements for the service. At the same time, a five -year contract would potentially help to drive down financing costs compared to other short-term contracts for services such as FFR and STOR. Within National Grid's Enhanced Frequency Response tender, there has been speculation that the cost of the service was driven down, at least partially, by a combination of contract length and an expectation of future revenue opportunities after the EFR contract ended.

- **Mobile units**: Based upon recent discussions with potential service providers and partners, we expect there are likely to be opportunities for service providers with mobile batteries or other portable technologies to be involved in RaaS. In principle, a single battery unit could be providing the service to multiple primaries, especially if there are multiple RaaS sites within a single geographic area. This would help to reduce even further the total value of the service. This would allow a dynamic approach to be taken to the size of the RaaS configuration to take into account seasonal and resilience variable.

Based on these assumptions we have made an estimate of what the cost of the service could be, to enable us to complete the CBA. As a starting point, we have assumed £6,000 per MW of demand per hour of battery size per year. This corresponds to about 1/8th of the capital cost of the battery. As outlined here, we believe this could be possible to achieve, however, this requires a well-defined commercial framework, enabling service providers to bid competitively for RaaS, stacking with other revenue streams.

Heat and transport electrification will increase reliance on electricity networks

Customers are becoming increasingly dependent on a secure and reliable source of electricity with the shift toward the electrification of transport and heat. Under the Consumer Evolution scenario which corresponds to increased grid services, 25% of customers vehicles in the SSEN licence area will be electric by 2030. Under a more conservative scenario, 7% of customers vehicles in the SSEN licence area will be electric by 2030. Some rural and remote communities also experience a seasonal influx of tourists from other regions, increasing future demand due to electric vehicles. For example, in Fort William, the population can more than double over the summer period due to tourism.

Additionally, it is clear from our stakeholder engagement that there is a growth in the digital economy and home-based working in many remote communities. Therefore, it is crucial for the long-term economic sustainability of these communities that they continue to have a secure and reliable electrical supply. It is essential that the industry develop new tools and techniques to maintain or improve network resilience and ensure that customers can shift toward the low carbon technologies to meet its target of net zero greenhouse emissions by 2050.

As we move towards the ED2 price control period, distribution network operation will transition to a more market-based approach. It is important that RaaS is developed and derisked now to ensure that the learning can be integrated into ED2 business plans.

Innovation funding is needed to de-risk the concept and achieve benefits

Where cost effective and technically viable innovations with understood risks exist, SSEN is always an enthusiastic adopter of these solutions.

The RaaS concept has not been demonstrated as a commercial or an integrated solution at scale, although the component parts have been tested. Small-scale deployments to date have been highly bespoke and customised solutions, delivered at a price point which is too expensive for at-scale delivery across the industry. In additional the attribution of commercial and technical risk in a solution that brings DNOs, Multinationals and Local communities together have to be defined and understood.

Mini-grids and microgrids are being implemented in many developing countries, however the technical design and business models are quite different. These are mainly for customers who have had no or very limited access to networks. The Brooklyn microgrid in the US is an example of a recently installed local energy system in a developed country. However, the microgrid is based on a model of peer-to-peer energy exchange rather than a market-services based approach to provide resilience to communities.

The RaaS concept is still untested and carries risk with no clear path to market for service providers, and there is no proven business model that identifies and addresses challenges (such as how RaaS could be stacked with other system services in a rural location in GB).

In order to procure RaaS, a range of interdependent technical and commercial aspects will need to be defined such as service requirements and standards for earthing and protection. The value of this service in the market alongside other services has not been tested. A holistic assessment of resilience as a service in a DSO context needs to be carried out while respecting the level of service that network connected customers expect

These challenges can now be addressed through this innovation project, led by SSEN in collaboration with stakeholders and experts from across the energy industry, to accelerate RaaS into BAU and deliver benefits to customers. Only a small number of deployments are needed for the project to cover the funding request, and this can easily be achieved within SSEN’s licence areas alone. However, there are clear potential benefits to DNOs throughout GB and, while not involved formally, WPD, UKPN, and NPg are all strongly supportive of the project. The programme we have set out will increase the Technology Readiness Level (TRL) of the RaaS concept from 6 to 8, through collaboration and research project involving the distribution networks and potential service providers.

Section 4: Benefits, timeliness, and partners

4 (a) Accelerates the development of a low carbon energy sector and/or delivers environmental benefits whilst having the potential to deliver net financial benefits to future and/or existing Customers

Key themes and benefits
RaaS will bring resilience improvements for customers. A GB-wide RaaS deployment will reduce CO_2 emissions by 16.6kT and save customers at least £240m by 2050.

4.1 Summary of benefits

This Project is designed to deliver benefits to a range of stakeholders:

- **Customers** will benefit from lower network costs as the cost of improving network resilience in remote and rural areas will reduce with the RaaS approach, compared to other existing and novel approaches.
- **Customers in remote and rural areas** will benefit from improved resilience, facilitating connection of low carbon technology and economic growth.
- **Flexibility Service Providers** will be able to access a new revenue stream. At the heart of the RaaS approach is the ability to allow service providers to "stack" revenues from differing markets and combine them, to improve overall commercial viability and to strengthen the investment case for RaaS. RaaS will provide new revenue opportunities for DERs in more remote locations on the network.
- **Renewable Generators** connected to remote networks will be able to continue to operate during outage periods, benefiting their revenue. In many areas it is necessary to disconnect renewable generation during fault or outage conditions as it is not possible to operate these alongside temporary diesel generation currently used for resilience.
- **GB DNOs** will gain a greater understanding of the technology, business models and commercial arrangements for use of Resilience as a Service. The Project will allow DNOs to further expand the growing portfolio of flexibility services being used to manage a wider range of network issues.

The method being trialled will deliver significant financial benefits to consumers compared with the base case. The cost benefit analysis (completed by TNEI) shows that:

- There is potential for **customers to save at least £146m by 2050**, if a GB wide implementation can take place. This is determined by calculating the cost of improving resilience using RaaS, versus other methods in the counterfactual.
- RaaS is **beneficial for 111 primary substations**, of the 114 candidate sites that we have identified. For these primaries, RaaS can provide a more cost-effective means of providing resilience out to 2050. The **average benefit is around £1.3m per site**, although for some sites this is over £2m.
- This leads to **16.6 kT of avoided CO2 (equivalent).** This is based on avoiding either the carbon embodied within traditional reinforcements, or the carbon released when running diesel generators to provide resilience. Candidate sites are allocated one of these base case solutions depending on site characteristics.
- The point at which the benefits from RaaS outweigh the funding request, i.e. the **'break-even', occurs after only 7 deployments**. If prioritising the sites with the most potential benefit, this may only require 4 or 5 deployments for break-even.

Further details on financial benefits are provided in Section 3 and appendix 1.

Base Case and Method Case costs

Table 1 shows the number of times each of the counterfactuals is deployed by DNO, and the number of times that RaaS is deployed when it is made available.

Table 1: Selected method for resilience, with and without RaaS

DNO	Total number of candidate sites	Without RaaS		With RaaS		
		Reinforce	DNO diesel/ battery	Reinforce	DNO diesel/ battery	RaaS

ENW	7	3	4	1	0	6
NPg	17	17	0	1	0	16
SPEN	19	9	10	0	0	19
SSEN	34	5	29	0	0	34
WPD	32	25	7	0	0	32
UKPN	5	5	0	1	0	4
Total	**114**	**64**	**50**	**3**	**0**	**111**

The assumptions for the cost benefit analysis are discussed in detail in appendix 2.

Additional Benefits

The CBA has generally used pessimistic assumptions, to represent a conservative view of the potential benefits. Therefore, the analysis does not consider some elements which could further increase financial benefits, such as:

- The possible need for life extensions of old plant in the counterfactual.
- The potential to reduce CI and CML costs for DNOs and the whole customer base The potential for a RaaS solution to defer load related network investment.

There are also further benefits that can be delivered from the use of a flexible solution such as RaaS including:

- **Optionality** – a traditional network construction solution once built is essentially fixed with limited options for future upgrade to respond to changes in energy consumption patterns and demand. In comparison, the use of a flexibility-based solution will allow DNOs to respond more flexibly to changes in future demand.
- **Seasonality –** an increasing issue with the electrification fo transport will be new seasonal peaks brought about by events and tourism. RaaS has the potential to be part of a seasonal response.
- **Permissions and Consents** – in most cases a conventional reinforcement solution will require wayleaves or servitudes to be secured for any potential additional overhead line or cable circuits. This will need to be supported by extensive stakeholder engagement to identify the most appropriate routes, particularly for long routes in rural areas. In many cases this will require a number of different route options to be developed before selecting the preferred route. In addition, it may be necessary to secure additional consents in environmentally sensitive areas. All of these factors can result in a prolonged period to design and secure consents, and obtain wayleaves for any new route, which can add additional cost and risk to these projects. Many of these issues will not apply to the RaaS solution, significantly reducing implementation times and potentially avoiding consenting costs. We have partially accounted for this by assuming that a portion (40%) of any new circuit route would need to be constructed using underground cable. This is detailed in appendix 2.
- **Environmental Benefits** – the RaaS solution will result in less disruption for customers due to avoiding the need for excavations or construction work in remote locations. This is in addition to the avoided use of embedded or temporary diesel power stations which will avoid any associated carbon emissions.

Importance of Resilience

GB networks are amongst the most reliable in the world; since 1990, the number and duration of power cuts has reduced steadily and significantly. Since 2002, the average customer is 50% less likely to suffer a power supply interruption; when they do, supply is restored much more rapidly. However, with the shift toward the electrification of transport and heat, customers will become increasingly dependent on a secure and reliable source of electricity. Additionally, our stakeholder engagement shows a strong growth in the digital economy and home-based working in many remote communities. Therefore, it is crucial for their long-term economic sustainability they continue to have a secure and reliable electrical supply.

(b) Provides value for money to electricity distribution/ transmission customers

Key themes and benefits
The Project will deliver over £140m in financial benefits across GB by 2050, and significant non-monetary benefits. Accurate Project costs have been calculated for a detailed work breakdown and formally reviewed using the partners' governance processes. Benchmarking against SSEN's existing framework supplier arrangements has ensured competitive staff day rates. To help ensure the Project generates best value for customers, a Stage Gate review at the end of Phase 1 will be undertaken prior to the RaaS solution deployment.

The Project will generate learning and develop tools that will deliver over £38m in financial benefits across the SSEN licence areas and £146m across GB by 2050.

RaaS represents a progression in the use of flexibility services in which DNOs procure services from providers to resolve network issues. This includes use of energy storage and distributed generation already connected to the network combined with advanced network control systems; in this case the DNOs want to reduce reliance on carbon-intensive standby generation in the most remote networks. The Project will inform network planning decisions and provide the commercial and technical tools to instil confidence in other GB DNOs to adopt the approach.

Understanding the use of flexibility services for providing network resilience will deliver new learning, to build upon the outputs from the Open Networks and other flexibility focussed DSO innovation projects such as TRANSITION, FUSION and EFFS. Therefore, the method will have a direct impact on distribution networks, improving resilience and maximising the utilisation of existing network assets through flexibility activities.

Project Costs
SSEN are confident that the Project represents good value considering the costs and likely incremental learning. The knowledge and learning plan described in Section 5 will ensure Project outputs are disseminated across a wide range of industry stakeholders, including the Open Networks project. To ensure this Project is delivered at a competitive cost, resource requirements have been calculated using a bottom-up approach. This is based on a detailed work breakdown structure and Project Plan, with inputs from SSEN, Costain and EON. Multiple levels of relevant internal stakeholders including senior management have reviewed the calculations. This was undertaken in accordance with SSEN's innovation governance process, and Costain's and EON's internal governance processes.

Our cost estimates are based on input from:

- SSEN on labour and resource requirements, including procurement, technical, legal and dissemination activities, based on extensive experience of past NIC, and LCNF projects;
- Costain on overall project management and supply chain development based on the company's experience of delivering innovative infrastructure projects; and
- EON, using their experience from the Simris microgrid project and other innovation projects as well as engagement with potential equipment suppliers.

We will use a competitive procurement process to select suitably-qualified suppliers for elements of the Project where several potential suppliers are available. This includes external research and analysis activity, as well as any required hardware and services. To avoid scope creep and cost overruns, where possible we will award the work in stages of fixed price and scope. The Project will be undertaken in two phases with a Stage Gate at the end of Phase 1. The first phase involves definition of requirements, stakeholder engagement and market consultation, IT architecture and integration requirements, trial site identification and specification of proposed trials. Phase 2 involves the deployment and trial of the RaaS solution across a number of trial scenarios.

The Phase 1 Stage Gate will consider a number of key issues. These include a check for continued alignment with the Open Networks objectives and other wider policy issues, the cost of trial deployments and evidence gathering, and a review of the business case based on the detailed design and requirements specification identified in Phase 1, considering the political and regulatory outlook. By the end of Phase 1 we will have consulted a wide range of stakeholders to review and test the Project's objectives. The Stage Gate will also check the Project will deliver the evidential base required to allow preparation for ED2. The majority of the cost of the Project are incurred in Phase 2 of the Project, therefore, the review of the business case at the Stage Gate will ensure that the Project continues to deliver the anticipated benefits before deployment costs are incurred.

The Project Steering Board will then make the decision on whether to proceed. This will require consensus from stakeholders, industry and regulators that the Project will achieve its objectives.

Figure 4 and Figure 5 show the costs for each phase of the Project by WP and Category.

Work Package	Phase 1 Spend (up to Stage Gate)	Phase 2 Spend (beyond Stage Gate)	Total Spend
WP1	498,974	1,041,560	1,540,534
WP2	285,138		285,138
WP3	813,285		813,285
WP4	298,565		298,565
WP5	525,056		525,056
WP6	34,517	607,154	641,671
WP7		5,402,249	5,402,249
WP8	180,921	548,144	729,066
Total	2,636,456	7,599,107	10,235,564

Figure 4: Costs for each phase of the Project.

Cost Category	Phase 1 Spend (up to Stage Gate)	Phase 2 Spend (beyond Stage Gate)	Total Spend
Labour	340,810	1,044,488	1,385,298

Equipment	205,000	2,894,160	3,099,160
Contractors	1,988,016	2,969,550	4,957,566
Travel & Expenses	102,630	374,390	477,020
Decommissioning		316,520	316,520

Figure 5: Project spend by Category.

The Project has secured input from a wide range of staff across the DNO and the Project partners. Both Costain and EON have reduced their standard day rates as a Project contribution. The average day rate for the Project for each partner is as follows:

- SSEN - £[redacted]
- EON - £[redacted]
- Costain - £[redacted]

In addition, SSEN has benchmarked these rates against existing framework arrangements with similar suppliers, acquired via the competitive procurement process.

It is worthwhile noting that a 'Call for Ideas' was released by the ENA on behalf of all GB licensees for this year's NIC. This call for innovation, whilst not forming part of a regulated procurement, provides evidence that SSEN has approached the broadest possible supply base. Appropriate commercial arrangements have been put in place with these partners during the bid development stage. These will be further developed if the Project is awarded NIC funding. Further details of the Project cost and work package breakdown can be found in Section 6 and appendix 2.

(c) Generates knowledge that can be shared amongst all relevant Network Licensees

Key themes and benefits
RaaS will produce significant incremental learning to expand the development of flexibility services and inform the Open Networks project. Potential RaaS applications have been identified in all DNO license areas.

i. The level of incremental learning expected to be provided by the Project

RaaS will produce significant incremental learning to expand the development of DNO procured flexibility services and inform the progress of the Open Networks project. The Project will provide learning in the following key areas:

- Data requirements and data exchange, building on Open Networks DSO functions mapped against current capabilities;
- Requirements to create a sustainable market that can facilitate competition based on energy system needs;
- The mechanism to help stimulate and develop the supply chain for delivery of these services;
- The monitoring and modelling requirements to provide network data, connectivity and constraint data in sufficient detail to allow the market to operate in different network types. Here the Project will build on learning from TRANSITION, EFFS and FUSION projects and other funded DSO projects, and on SSEN's BAU experience in deploying flexible solutions.

This shows RaaS will produce significant incremental learning.

ii. The applicability of the new learning related to the planning development and operation of an efficient Transmission System and/or of an efficient Distribution System to the other Network Licensees;

RaaS will help develop market and commercial models for the use of flexibility services to provide network resilience. This will build on outputs from the industry wide Open Networks project, as well as other NIC funded projects which support the transition to DSO. TNEI's RaaS business case development work has identified potential RaaS applications across all DNOs license areas. RaaS will fundamentally alter the methods of operating the network to secure resilience, and when successfully demonstrated will produce the best whole system outcome. Therefore, the learning from RaaS will be relevant to all network licensees.

iii. The plans to disseminate learning from the Project, both to Network Licensees and to other interested parties, with credit being given to innovative plans, tools and techniques which enable learning to be shared openly and easily with other Network Licensees;

Our detailed plans for dissemination are provided in Section 5. They include a variety of options to ensure the widest range of stakeholders are included. This is an area where SSEN has already identified the potential for sharing or coordinating dissemination activities with NPg's Microresilience NIA project. The Project has specific activities focussed on developing the supply chain to ensure that RaaS can be applied to BAU at the end of the Project.

iv. The robustness of the methodology to capture the results from the Project and disseminate the learning to other Network Licensees;

SSEN has established methodologies for knowledge capture which have been developed in our extensive portfolio of innovation projects, and this is outlined in Section 5.

v. The treatment of Intellectual Property Rights (IPR):

It is our intention that the work undertaken using NIC funding will adhere to the NIC default IPR arrangements as described in Section 5.3.

(d) Is innovative (ie not business as usual) and has an unproven business case where the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness

Key themes and benefits

Whilst the underlying technical solution has been demonstrated on the international stage, further work is required to address the technical challenges in providing network resilience during an outage. Further work is also required to develop the commercial arrangements, logistics and supply chain needed to adapt the approach to the GB market.

This Project is innovative in three respects:

- It is the first project to specifically address the network challenges by providing resilience as a service basis, based combining energy storage, renewable generation, flexibility and advanced network control;

- It will be the first project to demonstrate at scale 'island operation' with connected renewables and Battery Energy Storage System (BESS) maintaining supplies;
- It takes a holistic approach, looking at technology and business models to find solutions that work for all stakeholders across the supply chain .

The Project will address the scaling issues associated with progressing from technical demonstrations to business as usual operations. Robust business models will be established that are cost-effective for industry buyers and provide a sustainable financial return for suppliers. The models will drive development of explicit service specifications and technical standards, increasing the confidence of potential market participants to provide the service. The Project will also adapt the technical solution, proven in overseas demonstrators, for the GB market.

The commercial approach to providing resilience is innovative
Resilience is traditionally delivered by capital investment in new network infrastructure. In contrast, the Project will establish a RaaS delivery model, whereby GB DNOs will offer service contracts to stimulate investment in resilient energy solutions that allow sections of the network to operate temporarily as an islanded microgrid, reducing the impact of upstream faults and maintaining supplies to customers.

The development of the RaaS solution will create and add to the growing portfolio of viable and tested products which DNOs are able to procure to address network issues. The learning from the Project will allow DNOs to approach the market with standardised and well-defined requirements, enabling a number of market participants to easily understand the requirements and offer solutions .

A key Project consideration will be that RaaS will form just one of the elements of the business case for decentralised energy resources; a service provider 'value stack' model will be tested, whereby the RaaS provider sells services into other markets such as frequency response, balancing market or the other ancillary services. By giving access to alternative revenue streams, capital expenditure on RaaS provider's assets becomes more attractive for the investor which then lowers the cost of RaaS contracts. The Project will also define the roles and responsibilities of key participants in delivering the service (DNO/DSO, the RaaS Provider and supply chain), which requires new commercial arrangements for power and energy as part of a resilient system.

Without the learning from the Project there is a risk that each DNO will either be unable to procure resilience services or will create its own unique service description. This will impede market development and investment, leading to additional risk pricing and a fragmented market. This will risk a sub-optimal outcome for customers in terms of cost and security of electricity supply.

Local resilience services will be provided in the event of an upstream network fault; the resilience service provider will support an isolated section of the downstream network. The disconnected local portion ('islanded' portion) will comprise a variety of assets owned by different companies which must be able to operate as an integrated entity. This will require supporting commercial agreements, potentially between DNOs, RaaS Service Providers, and other Market Participants such as renewable operators, other power generators, demand-side response providers, and energy suppliers. Storage providers and the wider supply chain. This need creates uncertainty which market participants cannot identify, quantify and price. Innovation support is required to profile the risks, which can then be better understood to allow the new market to become established.

The technical approach to providing resilience is innovative
DNOs typically ensure resilience to their customers by establishing redundancy or high levels of interconnectivity in the distribution network. However, this is not always costeffective or practical in many rural areas, especially in remote or isolated communities. In many of these areas, DNOs rely on the use of mobile diesel generators if a loss of supply occurs or is predicted as a result of adverse weather forecasts. In extreme locations such as the Scottish islands and the Scilly isles standby diesel generators are owned and operated by the DNO.

The Project is innovative for GB because it will not employ traditional technical approaches for providing resilience. Instead, the Project will demonstrate a service-based approach which utilises already connected resource including energy storage technologies, augmented where possible by local renewable generation e.g. solar, wind. This will help reduce customer interruptions and customer minutes lost in these areas whilst reducing reliance on costly or carbon-intensive traditional solutions.

Whilst the discrete Project technologies are rated TRL8 or 9, and previous work demonstrates technical viability, this has not been done in the unique regulatory and operational GB context. In the GB industry environment, the solution is rated TRL6. However, when the Project is completed, the industry will have all the processes and systems needed to 'scale-up' effectively, and the technology will progress to TRL 8

The Project will inform the development of the technical standards for the deployment and operation of RaaS solution. Operating procedures and safety documentation will be documented for the demonstration site. These will include procedures for safely restoring the network after the islanded network is reconnected to the wider distribution network as any upstream fault is resolved. The Project will also establish a common set of definitions for describing the service's technical requirements for use by all DNOs. This will drive service standardisation and increase market confidence.

In summary, the commercial, technical, operational or regulatory risks associated with service delivery of microgrid RaaS in GB are significant. This means Network Licensees will not undertake the Project in their normal course of business and shareholders will not speculatively fund it. The GB market has reacted positively to the innovation but perceives significant risk in delivering the service. NIC support will help mitigate this risk so that RaaS can achieve widespread GB market penetration.

(e) Involvement of other partners and external funding

Key themes and benefits
Costain and E.ON proposed the Project via the ENA Joint NIC Call for Ideas, and NPg and SSEN expressed a strong interest. The companies then worked together to develop and submit the RaaS concept to the NIA. SSEN researched external funding opportunities from Scottish and UK Governments but none were appropriate to the scope of RaaS. SSEN will make a financial contribution to RaaS, as have EON and Costain who have made a significant contribution through formal reduction of their rates for the Project.

The SSEN innovation portfolio covers a wide spectrum of innovation areas. It continues to address key industry challenges, including the uptake of electric vehicles and other low carbon technologies, as well as the transition to a Distribution System Operator (DSO) model. RaaS represents the next development phase by extending SSENs existing portfolio of flexibility services to include resilience.

The Project was proposed by Costain and E.ON in October 2018 via the ENA Joint NIC Call for Ideas. Costain has worked across the energy networks industry for 25 years. As part of their ambition to become the UK's leading smart infrastructure solutions provider, Costain invested in researching and developing new solutions for DNO clients. During this global research, they identified E.ON's Simris project as a world leader so they approached E.ON with the intention of collaborating to develop an application in GB. After forming an initial proposal together, E.ON and Costain presented at the ENA Call for ideas which received interest from NPg, SSE, WPD and UKPN. Both NPg and SSEN expressed a strong interest to progress the Project. Subsequently, these companies worked together to develop and submit the RaaS concept to the NIC.

NPg wanted to develop the learning from their ongoing Microresilience project. However, it became apparent the concepts in that project were not sufficiently developed to support this year's NIC submission. In the best interests of the Project, NPg have agreed a smaller yet still important role. They will be involved in the Project Steering Group and RaaS team and provide learning from the Microresilience project; this will be valuable during Phase 1 and especially in the Stage Gate evaluation. The project will also look to share learning and build upon the progress of the Distributed Restart project.

The partners bring a wide range of skills and expertise (described in more detail in Section 6) which will ensure the Project meets its objectives. In addition, industry experts TNEI have been commissioned to develop the business case for the Project and to provide support in estimating the benefits delivered.

External Funding

SSEN will make a financial contribution to RaaS in addition to the significant time, effort and resource committed to the delivery of the Project. Both EON and Costain will provide further 'in kind' contribution [redacted]. During the development phase of the Project, SSEN investigated a number of potential external funding opportunities from Scottish and UK Governments. However, none were appropriate to the scope of RaaS and therefore were not pursued.

(f) Relevance and timing

Key themes and benefits

The near-term requirement for a resilient supply will strengthen as consumers increasingly rely on electricity to travel or heat their premises. RaaS providers will offer DNOs a much more cost-effective way to improve resilience. However, RaaS providers need standardised commercial arrangements and business models that stack revenues from other services. This work should be done now, while business models for flexibility from DERs are at an early stage.

It is not unusual for customers in rural and remote areas of the network have more supply interruptions, often with longer durations, compared to a GB average of around 30 minutes lost per year. SSEN has around 30 areas where it already adheres to an alternative security of supply standard (EM PO-PS-037) rather than P2 planning standard due to the high cost of providing network redundancy in these areas. We are committed to improving the resilience of remote and rural networks and have developed the RaaS concept specifically to address this. In our cost benefit analysis, we have identified 34 SSEN primaries where RaaS is cost effective, with another 80 across other DNO licence areas.

However, the value of access to a resilient supply of electricity is likely to strengthen in the near term as decarbonisation of other energy sectors means that consumers rely on electricity in order to travel or heat premises. Adoption of these technologies is expected to accelerate rapidly during the next distribution price control – by the end of 2028, there may be well over 1 million electric vehicles on GB's networks. Therefore, it is important the industry acts now to ensure that resilience can be provided for all customers – including those in remote areas – in the longer term. It should be noted that in these areas, supply interruptions generally cover larger geographical areas and have less access to other transport infrastructure and as a result have fewer viable alternative heating, EV charging or travel options available during interuptions.

SSEN are actively pursuing opportunities to use "flexibility" in lieu of traditional network reinforcement to address the new challenges that electrification will pose for the network. This is part of a commitment, made by all GB DNOs, to test opprtunties to contract flexibility when considering the reinforcement of the network. However, no significant work has been done on the commercial frameworks for using flexibility to provide network resilience. As discussed elsewhere in this document, it is possible that the requirements on a provider of such a resilience service could be very limited, meaning that a low cost could be possible. However, this requires contractual arrangements and business models which enable providers to easily "stack" with other services. There is a compelling opportunity for this to be done now, while the development of business models for flexibility from DERs is still at an early stage.

The RaaS Project will therefore contribute critical learning on resilience to the planning for the DSO Transition, alongside the Open Networks project as well as other industry projects.

If the Project is funded now and the method proves successful, RaaS will ensure that SSEN and other DNOs can cost-effectively provide a more resilient distribution network to consumers in remote and rural areas.

Section 5: Knowledge dissemination

Key themes and benefits

Interest in this Project was received from NPg, SSEN, SPEN and WPD, and later by UKPN, which illustrates that nearly all GB DNOs consider the Project to be a relevant, high-impact undertaking. Learning dissemination will be coordinated as part of the Project Stakeholder Management Plan by our overall Project Manager, Costain. To kick-start the UK RaaS market and maximise Project value, our team will disseminate learning and knowledge to all relevant stakeholders. GB DNOs will be the priority stakeholders, but others will be included, particularly companies involved in future RaaS delivery and operations.

Support from network companies is secured

The likelihood of a positive market reaction to RaaS has been increased by engaging key stakeholders during Project inception. Inclusion of DNOs is particularly important since they will be the primary user of the RaaS contract, which will be a key Project output. We achieved DNO involvement during the ENA NIC Call for Ideas, when NPg, SSEN, SPEN and WPD registered a strong interest on behalf of 10 of the 14 GB network licensees. Subsequently NPg and SSEN joined the Project team. DNOs have taken an active interest because the Project concerns cost-effective resilience services whilst aligning with DNO regulatory objectives, which is a fundamental issue for DNO operations.

Throughout the period January 2019 to July 2019, the four partners (E.ON, NPg, SSEN and Costain) have collaborated to shape the Project. For example, partner representatives attended regular workshops at sites across the UK at Birmingham, Cumbernauld in Lanarkshire, Manchester and York. However, NPG subsequently decided not to pursue the Project and focus on their ongoing Microresilience NIA project

The Project will demonstrate the technical viability of RaaS and complete a commercial exercise which will strengthen proof of the RaaS concept. This will also convince investors that a scalable market exists, help establish a common commercial delivery model across multi-party arrangements and prove the embryonic market can sustain itself after Project completion.

As the Project progresses, we will encourage collaboration with other GB Network Licensees, with the aim of moving RaaS into business as usual operations by the end of the Project. This will ensure the undertaking provides benefits to the whole GB network. The following sections describe our robust methodology to capture and disseminate the Project results to key stakeholders including Network Licensees.

5.1. Learning generated

We have identified a number of key incremental learning areas to be generated by the Project, these will be refined and further developed during Phase 1 of the Project. Figure 6 below outlines the learning in terms of type, capture method and applicability to other Network Licensees. This shows the level of learning from the Project will be significant, especially for Network Licensees in Great Britain.

Incremental learning 1	**Identify situations where RaaS may be a better solution than traditional resilience options.**
Capture method	The evaluation of potential solutions and their validation in 'real-world' operational demonstrators.
Applicability to Network Licensees	Informs DNO investment plans. For example, for the RIIO-2 period the Project findings may impact the balance between capital investment in traditional networks versus operating costs in procuring RaaS from the market.

Incremental learning 2	**An industry-standard set of technical and operational parameters for GB DNOs. These will allow DNOs to express their resilience needs for a specific part of an 'at-risk' network. Technology agnostic to enable business case evaluation of traditional reinforcement vs RaaS, and delivery via combinations of generation, storage and demand-side response.**
Capture method	Project technical parameters white paper / standard developed in consultation with GB DNOs and potential RaaS suppliers.
Applicability to Network Licensees	All DNOs experience challenges in delivering resilient networks, particularly in isolated rural areas.
Incremental learning 3	**Procedures for RaaS energisation, operation and deenergisation.**
Capture method	Captured during Project delivery; a key output in terms of new or revised standard operating procedures, safety bulletins and risk assessments. Useful to DNOs or their contractors who interact with electricity networks during outages and periods when normal supply is restored.
Applicability to Network Licensees	Safety is a primary objective for all GB DNOs. Islanding a rural network as a microgrid may require changes to procedures. This is because staff/contractors involved in service restoration using current standard operating procedures could mistakenly assume the network downstream of the fault in island mode may be de-energised, creating significant risk of harm.
Incremental learning 4	**How energy market participants (DNOs, generators, DSR providers, energy storage providers and their supply chains) can collaborate to deliver a technically integrated solution. Process defined for allocating and managing the risks that result from combining components into a complex system.**
Capture method	Model contracts and SLAs that outline RACI for different risks in RaaS system design, delivery, commissioning and operation.
Applicability to Network Licensees	DNOs will manage the network by procuring RaaS which uses the most cost-effective asset mix of storage, generation and DSR. Complex integrations may create risks or system behaviours that organisations other than the DNO are best placed to manage. The Project business model will ensure risks are allocated to the right party.
Incremental learning 5	**Optimised delivery models for RaaS in a GB DNO context.**

Capture method	The design build and commissioning of real-world microgrid demonstrators will include appraisal of organisational design options. In a GB context, to ensure effective delivery and operation of an integrated, interdependent resilience solution, the Project organisation will integrate the DNO, the RaaS provider, supply-chain and other relevant parties such as generators and DSR providers.
Applicability to Network Licensees	Improving confidence in the supply chain will benefit GB DNOs by enabling them to access RaaS more cost-effectively from a large, diverse supply chain. This will reduce cost, risk and dependence on single organisations.
Incremental learning 6	**The impact of RaaS on the 'value stack' of potential revenue streams for providers as they seek to build a strong, sustainable business case.**
Capture method	Modelling carried out by a capable third-party, which will inform business decisions by the Project RaaS Provider(s) regarding future commercial projects.
Applicability to Network Licensees	There will be a greater understanding of the DNO's costs in procuring RaaS solutions, whilst ensuring a sustainable business case for RaaS providers. DNOs will have a framework for comparing costs of providing resilience using RaaS and traditional methods. This framework will accommodate local network factors, the evolving value stack in the GB Electricity System, and the changing costs of resilience technologies.

Figure 6: Key incremental learning generated by the Project.

5.2. Learning dissemination

To maximise Project value, our team will disseminate learning and knowledge to all relevant stakeholders. GB DNOs will be prioritised, but other stakeholders will be included, especially companies potentially involved in future RaaS delivery or operations. As overall Project Manager, Costain will co-ordinate learning dissemination as part of the Project Stakeholder Management Plan. This will engage the right stakeholders in a timely manner, consulting with them as necessary, and providing relevant Project insights when appropriate.

Key Stakeholders

Our dissemination approach recognises that a key Project objective is to 'kick-start' a competitive market for RaaS provision. Therefore, our Project will engage with a broad range of stakeholders to increase industry confidence in the commercial viability of RaaS. To support this, the Project will develop a Stakeholder Advisory Panel whose remit will be to oversee development of a viable RaaS market as a key Project output. The panel will comprise key industry figures who will ensure industry stakeholders are properly consulted and informed. The panel will also help define the Project inputs and ensure sharing of learning on key topics such as:

- RaaS technical descriptions and service parameters;
- Safety, such as earthing and protecting people involved in network restoration;

- Keeping entry barriers low and market attractiveness high for market participants; and Ensuring DNOs as RaaS buyers have mechanisms to assure RaaS service providers deliver high quality services in a sustainable manner.

Key stakeholders could include regulatory bodies, GB DNOs, customers, the supply chain, RaaS Providers and asset investors. This stakeholder list also includes related NIC projects such as the 2018 NIC Project Distributed ReStart. Since this has similar characteristics to the RaaS Project, we will engage with the Lead Project Partner (National Grid ESO) to understand all project inter-dependencies. For example, we will identify any technical limitations or commercial incentives that impact black-start provision when microgrids are disconnected from the main network i.e. enter island mode.

The key Stakeholder Groups, dissemination channels and Lead organisations are shown in Figure 7 below.

Stakeholder group	Lead organisation	Dissemination Channels
Ofgem	SSEN	• Project reporting as set out in NIC Governance documentation • Project Steering Committee • Project Closedown Reporting
GB Licensees	SSEN	• LCNI Conference and similar industry events • Targeted workshops via the ENA
Supply Chain	Costain SSEN	• LCNI Conference and other conferences • Project Webinars or those provided by other industry participants • Targeted industry workshops Project web pages
RaaS & Asset Investors	Costain	Engage via industry associations such as EnergyUK, the ADE and Renewable Energy
Customers	SSEN	• Social Media • Project Webpage • Customer engagement events at trial locations

Figure 7: Key stakeholder groups and dissemination channels.

Encouraging collaboration across Network Licensees

To enable learning to be shared openly with other Network Licensees, a dedicated webpage will store key Project documents such as reports and presentations. A key deliverable which will be a new RaaS service outline template, which will be a valuable source of information to all GB DNOs, for example they could use the information to support planning activities. Our Project team will build upon the approach used by the National Grid ESO web-pages for Balancing Services[8], which illustrates existing industry best-practice for websites dedicated to individual services.

5.3. IPR

The RaaS Project will conform to the default IPR arrangements detailed in the Governance document.

[8] https://www.nationalgrideso.com/balancing-services

Section 6: Project Readiness

6.1 Evidence the Project can start in a timely manner

Key themes and benefits
The consortium of partner organisations has been assembled to provide the diverse experience and capabilities needed to deliver this large, multifaceted project. During the last 6 months, the partners have worked closely together on a regular basis to develop the concept and prepare the Project plan. These are well-developed, agreed by all partners, and provide evidence the Project can start in a timely manner.

The three partner organisations have invested significant effort in developing a plan to ensure the Project can start in a timely manner. Key plan elements are explained below.

1. Strong partner support
Following the Costain/E.ON presentation to the ENA NIC Open Call for Ideas in November 2018, the partners have collaborated closely to develop the Project, focussing on RaaS service design and technology solutions at multiple scales. This helped identify the relationship between the RaaS service design for different environments and technology solutions. The partners also identified ways to develop a competitive arena for RaaS service providers.

All partners supported the Project development by:

- Progressing the Project through their internal governance processes; this ensured stakeholder and senior management awareness and buy-in;
- Attending regular workshops across the UK; locations included Birmingham, Cumbernauld, Manchester and York; this provided sufficient face-to-face time to build positive professional relationships and develop the Project;
- Committing in-house specialists in key areas such as innovation management, energy storage, project management; all involved staff possessed high levels of relevant experience, which ensured Project development was informed by the best expertise available within the respective organisations.

The partners' commercial teams have been fully engaged from before the submission of the Initial Screening Proposal, through the planning phase and during development of this Full Proposal. An initial commercial agreement has been drafted with input from all parties which outlines the expected commercial relationships to support Project delivery, the governance model to direct the Project, and partner work package responsibilities. This will be further developed and agreed if the Project is funded.

2. A Capable project team
The consortium has been assembled to provide the diverse experience and capabilities needed to deliver this large, multi-faceted project. The Project team has compiled a detailed register of Project risks, which will be managed by the Project Manager and other identified individuals. Please refer to the outline risk register in appendix 13.

- Costain is a leading UK Construction company, delivering integrated leading-edge smart infrastructure solutions to meet national needs across the energy, water, transportation and defence markets. Costain will manage the Project's time, cost and scope on behalf of the partners, drawing on its experience as part of the GB energy sector project delivery and advisory services supply chain. As a DNO advisor, Costain's key value is to mediate and fuel the creation of a Resilience as a Service market for the GB DNO's. Costain will also bring the deliverability viewpoint on how best to reduce cost, time and risk. Costain has engaged their Highways, Rail and Defence businesses to identify best practices to benefit Project delivery, leveraging their extensive multi-sector expertise in smart infrastructure.

projects including the Blackburn Meadows **Costain will manage the project, drawing on its vast experience managing consortia and joint ventures**

Costain has managed successful delivery of complex infrastructure projects such as:

- £1.1bn A14 Huntingdon-Cambridge upgrade
- £100m Huntingdon & Peterborough Gas Compressor Upgrade
- £1bn London Bridge Station Redevelopment.

Costain will also draw on its substantial experience across the energy sector and others in delivering large, innovative technology projects such as:

- Highways A2/M2 Connected Vehicle Project
- Meridian 3 Autonomous Vehicles Pilot.

- E.ON is an international company based in Essen, Germany with a clear focus on Customer Solutions and Energy Networks. Its Innovation activities focus on these two segments and reflect its strategy of focusing on the new energy world of empowered and proactive customers, distributed and renewable energy, local energy systems and digital solutions. Two individual EON business units will participate in the Project namely E.ON Solutions GmbH (ESOL) and E.ON Business Solutions GmbH (EBU);

  ESOL focuses on bringing innovative products and services tailored for customer needs. The areas targeted are smart microgrids, home energy management systems, PV and battery, E-mobility, smart heating and energy network solutions. The Decentral Energy Systems (DES) Innovation team is responsible for innovative smart grid projects; Simris is part of this department.

E.ON provides the technical consultancy, commercial insights and market access based on multiple successful projects such as:

- Simris Microgrid: Wind-PV-Battery microgrid (Sweden)
- Interflex H2020: Extension of Simris with Demand Side Response, active customer participation (Sweden)
- 10 MW EFR Battery at Blackburn meadows (UK)

Moreover, relevant innovation projects are currently running, such as:

- iElectrix H2020: Smart grid and battery technology to increase penetration of renewables on constrained networks (Hungary, Austria, Germany, India).

- EBU specializes in integrated energy solutions for industrial, commercial and public-sector customers. The company offers tailored solutions in energy efficiency, on-site generation, virtual power plants, flexibility and battery storage. EBU brings in the market access, aggregation and commissioning experience, with Battery in UK, a lithium-ion battery with a capacity of 10 MW to provide enhanced frequency response

- SSEN will provide expertise in GB distribution networks and a deep understanding of real-world issues based on their extensive experience in managing networks in remote and challenging locations including the ground-breaking NINES project, as well as the learning from other DNO projects including NPg's ongoing Microresilience NIA project.

3. A well-developed project organisation

The Project team has developed a comprehensive Project Plan based on the extensive experience of the partners, for example E.ON's experience in delivering, commissioning and testing microgrid technologies. This plan will be actively managed and regularly updated during the Project phases.

The partners have agreed the work packages and a management and governance structure as shown in Figure 8.

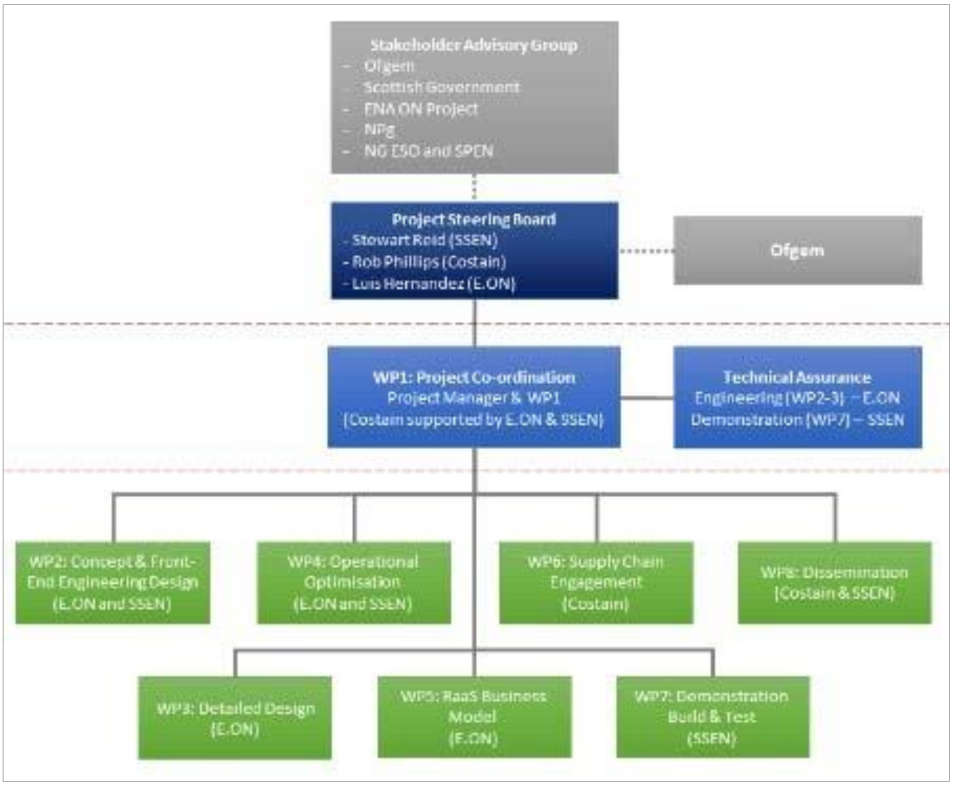

Figure 8: Work packages and management and governance structure.

To ensure effective Project governance, each work package owner has a clear reporting and escalation route through the Project Manager to the Project Board, comprising senior managers from each partner.

4. Strong technical experience

The Project employs technologies that have been proven in a relevant environment, although not in the complex GB commercial context. E.ON will transfer its experience from involvement in the Interflex Horizon 2020 Projects, including the **microgrid demonstration at Simris**, which showed how a utility-scale battery can provide power to customers when disconnected from the main network. The RaaS solution builds on NPg's **NIA-funded Microresilience Project**, which in turn builds on back-to-back power electronics developed for the **UKPN-led Flexible Urban Networks – Low Voltage (FUN-LV) Project**.The project will also build and develop the requirements from the ongoing NGETSO NIC project – Distributed ReStart.

5. Effective stakeholder engagement
This Project brings together partner organisations that represent the majority of a future supply chain for RaaS solutions.

The learnings captured and disseminated to the wider industry as outlined in section 5 will encourage companies with the right capabilities to enter other positions along the RaaS value chain. The investment case will be better-understood, which will drive down risk and cost in the supply chain.

6. Candidate sites identified
Figure 9 presents the candidate sites already identified during the business case development for this bid. It highlights that RaaS is most beneficial in cases where demand is low (which keeps the total cost of the RaaS service low) and EHV circuits are long (which pushes up the cost of the reinforcement counterfactual). These candidate sites have been identified using information contained in each DNO's published Long Term Development Statement (LTDS).

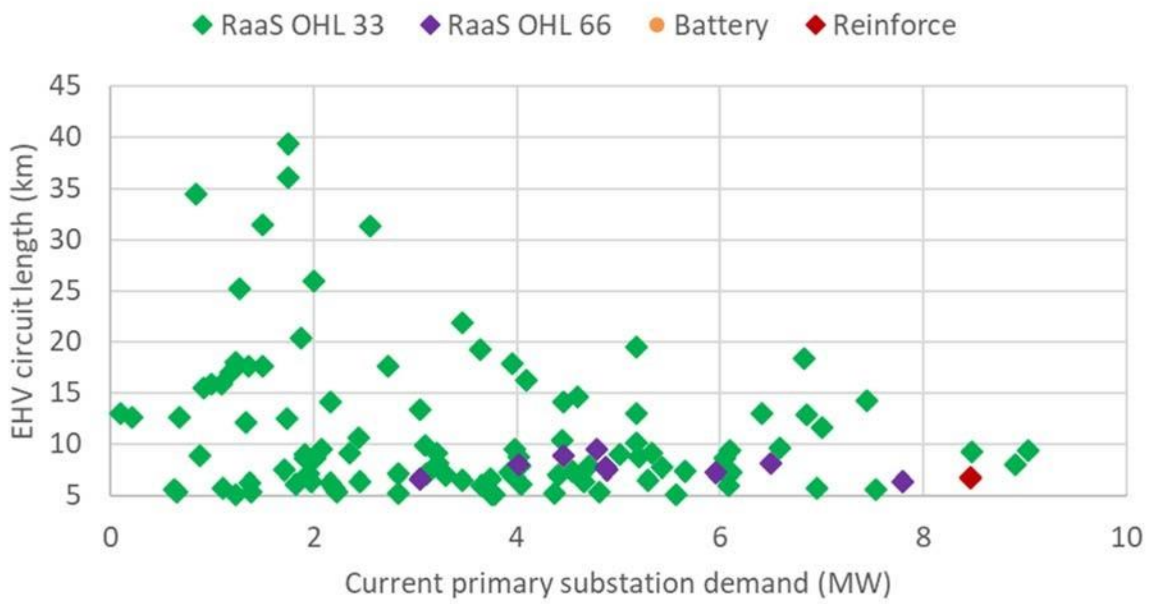

Figure 9: RaaS candidate sites in CBA, by demand and EHV circuit length

6.2 Project planning and work packages

An initial detailed Project Plan outlining activities, milestones and dependencies has been produced, and is attached in appendix 11 (the Project Programme is contained in appendix 12). This will be continually reviewed, refined and maintained as a fully comprehensive, accurate and up-to-date plan for delivery.

The Project will be undertaken in two phases with a Stage Gate at the end of Phase 1. The first phase is focused on (i) confirming the location for the first trial site (ii) developing the engineering design for the first RaaS solution from concept to detailed design (WP2 & WP3), and (iii) the business model and investment case for the RaaS supplier. These work packages are described in Figure 10 and Figure 11 below.

Phase 1 work packages have been assigned key Project milestones. Performance of the Project against these milestones will highlight emerging risks, potential cost overruns and potential benefit shortfalls. The Work Packages will then escalate any change requirements to the Project Steering Board using the approach in appendix 11. All outputs from Phase 1 will be informed by focussed stakeholder engagement and Open Networks outputs. The outputs will use common language models where relevant and will be widely disseminated to ensure awareness and buy-in from potential RaaS providers, their supply chains and other DNOs.

Work package	Scope
WP1 Project Coordination	WP1 contains all core project management activities carried out by each partner, with Costain leading the overall coordination.
WP2 Front-End Engineering Design (FEED)	Initial design phase for the proposed method forming the foundations on which the detailed design for the demonstrator should build. WP2 will include the following high-level tasks: • Define resilience service use case(s) for the demonstrator • Demonstrator site selection and proposal development Functional specification of RaaS Service including Energy Management System (EMS), service windows, KPIs and control system integration
WP3 Detailed Design	Detailed design concentrates on the technical design of the method and setting of the parameters in which the trial will operate. WP3 will include the following high-level tasks: • Identification and qualification of potential equipment suppliers • Detailed design of controls, electrical integration, available distributed energy resources (DER) and the BESS • Supplier selection and Energy Management System (EMS) development • Construction, integration, commissioning and testing plans for the demonstration • Development of Trial Programme • Health & Safety assessment
WP4 Operational Optimisation	The conversion of market forecasts into optimised operational schedules and best cost-benefit compromise. WP4 will include the following high-level tasks: • Scenario definition for future flexibility landscape • Market analysis, impact on industry arrangements and techno-economic modelling for defined scenariosDemonstration platform development and market integration.
WP5 Business Model	Detailed Design, Operational Optimisationand Market Feedback outputs are brought together and expanded to form the Business Model for potential RaaS suppliers.

	WP5 will include the following high-level tasks: Build investment business case for RaaS supplier with inputs from WP4 and market feedback from WP6 Develop initial RaaS contract for Demonstrator Update DNO business case.
WP6 Supply Chain Engagement	The Supply Chain Engagement and investigation into the GB RaaS market and its commercial risks for new participants. Phase 1, WP6 will include the following high-level tasks: • Investigation into the full potential of RaaS across GB • Develop enterprise design of the future RaaS market • Model and simulate commercial risks of RaaS market propositions and situations • Supply Chain Mapping of potential RaaS market and Stakeholder engagement on learning outcomes.

Figure 10: Phase 1 work packages

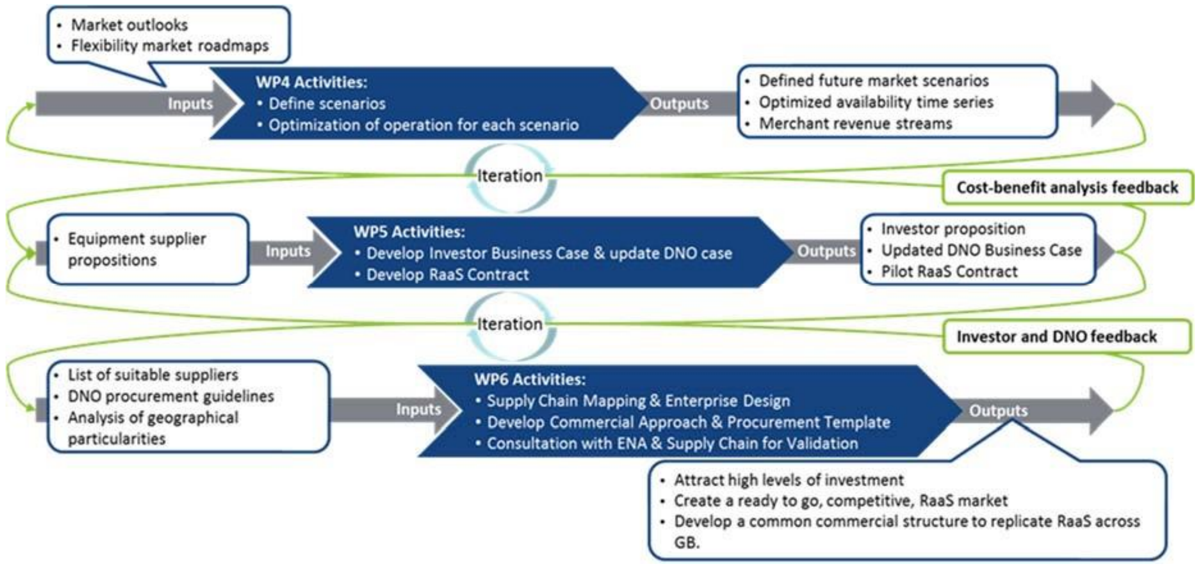

Figure 11: Market Modelling

Strong feedback loops exist between the technical, operational, economical and supply chain optimisation. The outputs from the work in Phase 1 will also inform a Stage Gate Review. Importantly, this acts as a precursor to the final investment decision to build, commission and test the RaaS assets at the trial location. The Stage Gate Review will include a check for continued alignment with the Open Networks Project, incorporate learnings from other relevant projects such as the NPg Microresilience NIA project, consider wider policy and regulatory issues, the cost of trial deployment, and a review of the business case based on the detailed design and requirements specification identified in Phase 1. By the end of Phase 1 we will have consulted a wide range of stakeholders to review and test the Project’s objectives. The Stage Gate will also check that the Project will deliver the evidential base expected for RIIO-ED2.

Following the Stage Gate Review, Phase 2 focuses attention on the construction, commissioning, testing and evaluation of the RaaS demonstration at the chosen site, plus developing and exploiting the learnings to accelerate the development of the RaaS market and facilitate transfer to a ‘business as usual’ (BAU) context.

Phase 2 will result in the construction of a commercial RaaS demo (WP7) site. [redacted] SSEN will take over responsibility for the connection of the demonstration assets to the network, with E.ON DES providing technical advice, based on the learnings of their previous projects. Once commissioned, the system will be tested according to the test plan developed during Phase 1, to demonstrate how it fulfils the commercial and technical requirements captured in Phase 1.

During Phase 2, WP6 will take the lessons learnt so far in the Project to stimulate the supply chain and ready the market for the adoption of RaaS as a BAU solution. WP6 is fundamental to delivering a scalable BAU solution for GB DNOs and creating a sustainable competitive market of RaaS providers. WP6 will identify how delivery of the first trial might be improved in terms of commercial arrangements, design and delivery, and use this knowledge to drive a procurement activity for a proposed second trial site. This is planned to include consultation with potential RaaS market to test the replicability of the arrangements for the first trial, engagement to improve awareness of the potential RaaS market and identification of improvements to the commercial, delivery or operational models. Costain will lead WP6 having cross-sector supply-chain engagement experience, but no direct commercial interest in the provision of RaaS solutions, and hence can be seen as a neutral partner. WP6 is planned to end after the procurement exercise for a second RaaS site concludes, leaving the second site to be potentially delivered via SSEN's BAU activities. Figure 12 below shows the Phase 2 work packages.

Work package	Scope
WP6 Supply Chain Engagement	Accelerating the pace of RaaS market development by ensuring all DNOs and other potential RaaS Providers have the skills, tools and confidence to invest in, procure or provide RaaS solutions. Phase 2, WP6 will include the following high-level tasks: • Publish P13 Enterprise Model and receive feedback from potential market participants • Develop optimal commercial and procurement model for future iterations of RaaS • Formal consultation on commercial strategy, investability of market opportunity, enterprise model and procurement methodology with potential RaaS providers and supply chains • Set procurement strategy for BAU procurement of RaaS and initial design work for second demonstration.
WP7 Demonstration Build & Test	Construction of the demonstrator and its implementation based on the Detailed Design and Trial Programme. Trial 1 is a physical demonstration of the Primary RaaS method while Trial 2, built on Trial 1 learning, goes to the open market for the RaaS service in an alternative location. If procurement is successful and economically viable for all parties, SSEN will seek to build out key components of Trial 2 through BAU funding. WP7 will include the following high-level tasks: • Procurement of assets, products and services • Permitting and construction of RaaS and network assets • System integration, commissioning and testing • Operation, Monitoring and optimisation

	Conclusion of the trial, via decommissioning of assets or transfer to business as usual.
WP8 Dissemination	WP8 contains all dissemination and documentation for the Project as a whole and all work package specific activities. • Dissemination will occur throughout the Project by way of webinars, presentations and relevant events • Dissemination will be carried out in conjunction with other relevant innovation projects and the Open Networks Project at key stages of the Project.

Figure 12: Phase 2 work packages

6.3 Project governance and quality assurance

A Project organisation chart has been developed which details the governance and management arrangements and is attached in appendix 10 and Figure 12 above. Upon selection of the suppliers and resources, the organisation chart and responsibilities will be assigned to the appropriate resources. Note this is not an exhaustive list, and we will welcome representatives from Ofgem on the Project Steering Board.

Roles and responsibilities are described as follows:

- A **Project Steering Board** comprising the key stakeholders and decision makers within SSEN, E.ON and Costain. This group is ultimately responsible for the Project and will make decisions that have an overall impact on the benefits and outputs the Project will deliver. They will assess major change requests, review the impact on the Project business case, and identify and review risks or issues associated with major change requests.
- A competent **Project Manager** has been identified by Costain and will be responsible for managing key Project tasks and activities. The Project delivery team will be supported by a Financial Controller and a Project Management Officer. Monthly reporting to the Project Steering Board by the Project Manager will allow full financial and project control. The Project Manager will undertake a **regular risk review** with results reported to the Project Steering Board. The Project Manager will prepare an active risk register, with mitigation and contingency plans in place. This will be continually reviewed and refined to ensure it is maintained as a fully comprehensive, accurate and up-to date reflection of project risks and mitigations in place for Project delivery.
- A **Stakeholder Advisory Group** will provide strategic oversight to the Project ensuring that it remains relevant and delivers learning to the GB DNOs and the wider electricity sector. This Group will involve NPg as well as the NGETSO Distributed Blackstart project to ensure continued alignment with the NIA Microresilience project.
- For each work package, a **work package delivery team** will be set-up for the day today undertaking of tasks within the work packages reporting directly to the work package manager. Interdependencies between work packages will be highlighted in the fully developed Project Plan and work package managers will be responsible for maintaining coordination between work packages with support from the Project Manager.
- **Quarterly Project Partner/Supplier Reviews** will track and discuss progress and risks to Project delivery.

- **Risk Assessment Workshops** will be rigorously conducted for all stages. Reviews will be in the format of workshops with the output captured within the Risk Register. The register issues, actions and ownership records will be readily communicated amongst the team. The workshops will identify risks and significant risks to the Project Steering Committee.

The potential for cost overruns, materialised risks and risks for customers will be limited by the two-phase approach with a stage gate review following phase 1 and robust project governance around specific milestones.

6.4 Senior management commitment

The Project has been developed in conjunction with senior management teams at SSEN, EON and Costain. They have demonstrated full commitment to the Project and ensured the availability of input and support from in-house specialists, with substantial commitment of their own resources to developing the Project to date. Management commitment has been achieved through regular presentations at executive management team meetings and also at senior management team meetings within relevant directorates.

SSEN, E.ON and Costain senior management have all provided inputs on the Project scope, delivery phases and success criteria. The experience and guidance in their areas of expertise has enabled preparation of a robust Project. Senior managers from each partner will sit on the Project Steering Board and Stakeholder Advisory Group.

6.5 Verification of information in the bid

SSEN has endeavoured to ensure all of the information included within this full submission is accurate. Information included within the proposal has been gathered from within SSEN, the Project partners, suppliers and other subject matter experts. All of this information has been reviewed to confirm and refine understanding, whilst evaluating the validity and integrity of the information. The Project cost estimates (further detailed in appendix 2) have been based on:

- Inputs from sector specialists and advisers external to SSEN
- Inputs from SSEN specialists
- Quotations received from the partners and suppliers, benchmarking where possible and utilising procurement expertise in specific areas to challenge costs and leverage existing commercial arrangements with suppliers
- External and internal expert knowledge of the typical cost requirements from ICT projects.

The bid team has worked with the partners to prepare and review the bid. Project partners have also ensured information provided by them has been through a thorough internal review and approval process before being provided to SSEN.

The carbon and financial benefits case outlined in Section 3 and supported by appendix 2 has been developed by TNEI with input from SSEN and the Project partners. At all stages, the business case has been critically examined to ensure a prudent and defensible approach has been taken; this is explained in more detail in appendix 1.

6.6 Dependence of learning on uptake of low carbon technologies

The studies undertaken by TNEI have indicated a broad range of sites across GB where a RaaS solution would deliver benefits. This is based upon a number of factors including local demand and the site location. However, the primary consideration is the network feeding arrangement of a single feed with limited or no interconnection. Therefore, the Project has no major dependency on the uptake of LCTs. Nevertheless, TNEI have undertaken a sensitivity analysis on the business case which covered the four FES scenarios and also altered the cost base for the Project. Each case still produced a positive business case. This is described in further detail in appendix 1.

6.7 Processes to suspend or halt the Project

Any circumstances which constitute a significant change or new risk to Project budget, programme or learning outcomes will be identified and managed using the governance processes detailed in appendix 10 and appendix 11.

Any decision to request a suspension of the Project would be made by the Project Board and submitted to Ofgem for approval together with all relevant information, such as the specific actions required, budget update, and customer impact. As specified in paragraph 8.44 of the NIC governance document, we will aid Ofgem's evaluation of any suspension request by providing all relevant information such as the specific actions required, likely costs incurred, and whether suspension would be in the best interests of customers. A suspension request may occur as a result of:

- A Key Learning Outcome arising from delivery of a Project work package, which will be timed to coincide with Project Board meetings
- A Project Stage Gate Review shown in Figure 13 which will consider the business case, risks, issues, benefits realisation and financial position.
- Ad-hoc escalation of risks and issues, via the Risk and Issue Management process laid out in our Project Management Plan in appendix 11. Circumstances which require the Project to be suspended include:
- The Project fails to deliver the expected financial and technical benefits
- The solution design and implementation are too complex
- Equipment and systems integration takes too long or is unachievable
- Suitable trial sites are unavailable
- Project costs are too high
- Technology substitutes appear which promise superior value.

Stage gate

2020		2021	2022	2023
Feasibility and FEED	Detailed design	Procurement, installation and commissioning	Testing and operation	

Stage Gate – Stop, Modify or Proceed

✓ Check for continued alignment with the Open Networks Project and industry

✓ Incorporate learnings from other relevant projects

Figure 13: RaaS Project timeline showing decision gates at the end of each phase.✓ Consider wider policy and regulatory issues *If the Project does not meet the mandatory evaluation criteria, the Board may place a Project* ✓ Refine the cost, risks and

programme for trial deployment *suspension request with Ofgem.*✓ Review the business case.

Section 7: Regulatory issues

Key themes and benefits
No derogation, licence consent, licence exemption or a change to the current regulatory arrangements are needed to implement the Project. Any regulatory issues that arise during Project delivery will be escalated to Ofgem before proceeding. Any regulatory changes after Project completion needed for viable RaaS business models will be identified and addressed through the normal channels.

7.1 During the Project

The electricity distribution system must be operated in a manner that ensures network security and the safety of customers and the publicConditions and technical requirements include, but are not limited to, the Grid Code, Electricity Safety, Quality and Continuity Regulations 2002 (ESQCR), the NETS Security and Quality of Supply Standard (SQSS), the Distribution Code. Security of Supply standard (P2). Engineering recommendations G59 and G99, and the ENA guidance on resilience are particularly relevant to this Project.

We anticipate all regulatory or documented industry standards will be met during the initial Project phase, which concerns installation and in-depth trial design. The outcomes of this phase will be periodically reviewed against all relevant standards to ensure ongoing compliance after the Project moves beyond phase one into engineering implementation and installation. While no issues are anticipated, any that arise will be mitigated by design, and where this is not possible will be escalated to Ofgem before we proceed, this assessment will be included within the assessment at the proposed Stage Gate.

Whilst planned outages will likely be needed to facilitate engineering installation and potentially live trials of various use cases, these will be planned to minimise any interruption to customers' supplies. Any outages will be managed via the current operational procedure to ensure compliance with normal operating standards.

Additionally, this project will have an impact on the settlement arrangements for islanded networks following a fault. Through increased use of metered assets to meet demand (as opposed to unmetered diesel), the project should result in a slight improvement in overall system imbalance compared to the current case. At the moment the volumes anticipitaed to be traded due to rollout of RaaS are relatively modest in the GB context, resulting in de-minimis impact on GB settlement. However, as the use of RaaS increases across GB, the impact on settlement needs to be understood. RaaS will provide data towards understanding the scale of this imbalance and inform other industry work on the impact of flexibility services on settlement including Open Networks Project WS1A and WS1B.

7.2 After the Project

To encourage provision of resilience services by third parties, a key Project objective is to identify viable business models for the preferred technical solution. Any required changes to regulation or engineering standards to facilitate this under normal network operational conditions including procurement obligations, technical requirements and industry rules will be identified and addressed through the normal channels.

Section 8: Customer Impact

Key themes and benefits
Robust contingency plans will be adopted in the unlikely event the solution does not perform as planned. Customers will be kept fully informed, with dedicated contact channels for customer queries. Supply interruptions will be minimised using all practical steps.

8.1 Interaction and engagement with customers

The Primary RaaS solution will be connected at 11kV at the selected Primary Substation. The key interaction will be between the DNO and RaaS Service provider, which will be subject to the terms of a mutually acceptable bilateral commercial contract for the delivery of the trial deployment. This will also include any commercial arrangements with any suitable renewable generators connected to the trial network.

8.2 Planned and unplanned interruptions

The RaaS Project will involve planned work at the selected Primary Substation location; it is envisaged that all of the construction works and associated commissioning works will be delivered without interruption to customers' supplies. This will be achieved either by back-feeding supplies from an adjacent circuit or by deploying a temporary generator for the duration of our installation activities.
To ensure the RaaS solution can be adopted into business as usual operations by DNOs, the Project must prove the system works during an unplanned interruption to supply, that is, a fault. Therefore, to fully prove the operation of the system we will need to introduce a fault by disrupting the supply, test that the system can operate successfully as an islanded network, and then successfully transition back to normal operation.

Vulnerable customers

Prior to any works or trials on the network, we will consult the Priority Services Register to identify vulnerable customers who may be impacted. We will take all practicable measures to configure the trial network to exclude these customers; where this cannot be done we will offer support, for example by providing standby generators.

Every effort will be made to ensure that supplies to customers are not compromised during this trial operation. Security of supply is of critical importance to the Project team and the trials will only proceed when risks are reduced to an acceptable level. To minimise impact on customers and ensure zero impact on customers with priority needs, a number of mitigations will be undertaken. These include:

- Reconfiguring network controls to enable switching to minimise the number of customers who experience a supply interruption;
- Undertaking desktop modelling as part of trial planning. This will include a detailed consideration of network connectivity, customer numbers, number of Priority Services Register (PSR) customers, customer types, and sensitive loads to ensure that the site is appropriate for the trial.

These mitigations will be augmented with robust contingency plans on in the unlikely event the solution does not perform as planned. These contingency plans will include additional staff being positioned to manually restore supplies and the potential use of temporary generation to deal with any unintended consequences.

Section 9: Project Deliverables

1.1. Table 2: Project Deliverables

Ref.	Project Deliverable	Deadline	Evidence	NIC funding request
1	Front End Engineering Design (FEED) (WP2)	August 2020	1. Report detailing the selected site for demonstration and proposed Use case(s) for the RaaS demonstration. 1. External peer review of FEED.	4%
2	Detailed Design (WP3)	January 2021	1. Detailed design of controls, electrical integration, available DER and the BESS complete. 2. Publish Trial Programme on SSEN RaaS webpage.	7%
3	Business Model for potential RaaS suppliers (WP5)	February 2021	3. Construct investment business case for RaaS supplier. 4. Produce draft Heads of Terms for RaaS method.	7%
4	Stakeholder Feedback Event (Stage Gate)	April 2021	1. Stakeholder feedback event to disseminate and gather feedback on outputs.	6%
5	Supply Chain Engagement (WP6)	November 2021	1. Publish Commercial Strategy on SSEN RaaS webpage. 2. Present Enterprise design for Resilience as a Service on SSEN website	6%
6	Network Adaptation and Acceptance Testing (WP7)	March 2022	1. Produce interface and configuration specifications and commissioning reports.	41%
7	Trial 1 – Demonstration at first site complete (WP7)	December 2023	1. Publish Demonstration analysis results on SSEN RaaS webpage covering both technical and commercial aspects. 2. Stakeholder dissemination event showcasing learnings.	25%

8	BAU Preparation	June 2024	1. Technical design to support second demonstration site. 2. Consultation with potential RaaS market for second demonstration site.	4%
Ref.	**Project Deliverable**	**Deadline**	**Evidence**	**NIC funding request**
9	Comply with knowledge transfer requirements of the Governance Document.	End of project	1. Annual Project Progress Reports which comply with the requirements of the Governance Document. 2. Completed Close Down Report which complies with the requirements of the Governance Document. 3. Evidence of attendance and participation in the Annual Conference as described in the Governance Document.	N/A

Appendix Contents

Appendix 1: Benefits Tables

The method being trialled will deliver significant financial benefits to consumers compared with the base case as shown in Table A1. There is potential for customers to save at least £146m by 2050, if a GB wide implementation can take place, with 16.6 kT of avoided CO2 (equivalent). The point at which the benefits from RaaS outweigh the funding request, i.e. the 'break-even', occurs after only 7 deployments. RaaS does not inherently release network capacity although the system could also be utilised for load balancing to defer network reinforcement. However, we have not included this as a benefit because the use of batteries to defer reinforcement has been assessed in other innovation projects and RaaS is focussed on resilience as a service.

The CBA which developed by TNEI to calculate the benefits has used pessimistic assumptions, so represents a conservative view of the potential benefits. The analysis does not consider some elements which could increase financial benefits, such as:

- The possible need for life extensions of old plant.
- The potential to reduce CI and CML costs for DNOs and customers and.
- The potential for a RaaS solution to defer load related network investment.

It is based on load growth and LCT uptake identified in the 2018 Future Energy Scenario for energy system change – Community Enhancement which is most representative of likely uptake for rural and remote networks. The base case (counterfactual) and method both assume that other innovations will be used where efficient to reduce overall demand in the resilience zone, for example with the use of energy efficiency as being trialled in SSEN Social CMZ NIA project, or by the use of Smart Charging for EVs. However, as the project is primarily looking at resilience the counterfactual is therefore, based on the provision of additional infrastructure to provide the necessary level of redundancy.

RaaS Financial Benefits

Scale (£m)	Method	Method Cost (£m)	Base Case Cost (£m)	Benefit (£m)			Notes	Cross Ref.
				2030	2040	2050		
DNO Benefits -Pilot	1	1.38	2.70	1.80	1.58	1.32	See surrounding commentary	
DNO Benefits -Licensee	1	28.38	67.26	38.80	41.56	38.89		
DNO Benefits -GB Wide	1	161.63	307.99	200.29	175.39	146.36		

Table A1: Financial benefits calculated for the RaaS method

RaaS has been found to be beneficial for 111 primary substations, of the 114 candidate sites that we have identified. For these primaries, RaaS can provide a more cost effective means of providing resilience out to 2050. Candidate sites have been identified through analysis of GB DNO LTDS, focussing on 33kV networks with no redundancy, a single

33kV circuit with a length of over 5km and no 11kV interconnection. Further details on the methodology to estimate the benefits are provided in Section 3 and Appendix 2.

RaaS Capacity Released

Scale (GW)	Method	Method (MVA)	Base Case (MVA)	Benefit (MVA)			Notes	Cross Ref.
				2030	2040	2050		
DNO Benefits -Pilot	1	N/A	N/A	N/A	N/A	N/A	See surrounding commentary	
DNO Benefits -Licensee	1	N/A	N/A	N/A	N/A	N/A		
DNO Benefits -GB Wide	1	N/A	N/A	N/A	N/A	N/A		

Table A2: Calculated capacity released from the RaaS method

The RaaS Method does not anticipate any release of capacity through its implementation. This assumption shall be tested through WP7, Trials Construction and Operation.

RaaS Carbon and Environmental Benefits

Scale (ktCO2e)	Method	Method (ktCO2e)	Base Case (ktCO2e)	Benefit (ktCO2e)			Notes	Cross Ref.
				2030	2040	2050		
DNO Benefits -Pilot	1	0.00	0.15	0.15	0.15	0.15	See surrounding commentary	
DNO Benefits -Licensee	1	0.00	1.45	1.45	1.45	1.45		
DNO Benefits -GB Wide	1	0.63	17.27	16.64	16.64	16.64		

Table A3: Carbon and environmental benefits calculated for the RaaS method

Base case and Method costs and carbon are based on up to date industry data with the Method assumed to provide up to 12 hours of resilience plus require enabling works on the DNO network. Further details on the methodology to estimate the benefits are provided in Appendix 2.

Appendix 2: Method and Base Case Methodologies

[redacted] *Section redacted* [redacted].

Appendix 3: Work Package Descriptions

Work Package	Lead Partner	Scope Summary
WP1 Project Coordination	Costain	WP1 contains all core project management activities carried out by each partner, with Costain leading the overall coordination. Key focus areas will be: • Stakeholder engagement • Requirements analysis and definition • Risk, opportunities and issues management
WP2 Front-End Engineering Design (FEED)	E.ON and SSEN	Initial design phase for the proposed method forming the foundations on which the detailed design for the demonstrator (Trial 1) should build. WP2 will include the following high-level tasks: • Define resilience service use case(s) for the demonstrator • Demonstrator site selection and proposal development • Functional specification of RaaS Service including Energy Management System (EMS), service windows, KPIs and control system integration
WP3 Detailed Design	E.ON and SSEN	Detailed design concentrates on the technical design of the method and setting of the parameters in which the trial will operate. WP3 will include the following high-level tasks: • Identification and qualification of potential equipment suppliers • Detailed design of controls, electrical integration, available distributed energy resources (DER) and the BESS • Supplier selection and Energy Management System (EMS) development • Construction, integration, commissioning and testing plans for the demonstration • Development of Trial Programme

WP4 Operational Optimisation	E.ON	The conversion of market forecasts into optimised operational schedules and best cost-benefit compromise. WP4 will include the following high-level tasks: • Scenario definition for future flexibility landscapes • Market analysis, impact on industry rules and techno-economic modelling for defined scenarios • Demonstration platform development and market integration
WP5 Business Model	E.ON	Detailed Design, Operational Optimisation and Market Feedback outputs are brought together and expanded to form the Business Model for potential RaaS suppliers. WP5 will include the following high-level tasks: • Build investment business case for RaaS supplier with inputs from WP4 and market feedback from WP6 • Develop RaaS contract for Demonstrator • Update DNO business case
Stage Gate – Stop, Modify or Proceed ✓ check for continued alignment with the Open Networks Project and industry ✓ incorporate learnings from other relevant projects ✓ consider wider policy and regulatory issues ✓ refine the cost, risks and programme for trial deployment ✓ review the business case		

WP6 Supply Chain & Engagement	Costain	Accelerating the pace of RaaS market development by ensuring all DNOs and other potential RaaS providers have the skills, tools and confidence to invest in, procure or provide RaaS solutions. Trial 2, built on Trial 1 learning, goes to the open market for the RaaS service in an alternative location. If procurement is successful and economically viable for all parties, SSEN will seek to build out key components of Trial 2 through BAU funding. WP6 has two phases (one pre- and one post-Stage Gate) and will include the following highlevel tasks: • Investigation into the full potential of RaaS across GB • Develop enterprise design of the future RaaS market
		• Model and simulate commercial risk of RaaS market propositions • Supply Chain Mapping of potential RaaS market and Stakeholder engagement on learning outcomes • Publish P13 Enterprise Model and receive feedback from potential market participants • Develop optimal commercial & procurement model for future iterations of RaaS • Formal Consoltation on commercial strategy, investability of market opportunity, enterprise model and procurement methodology with RaaS providers and supply chain • Set procurement strategy for BAU procurement of RaaS and Design initial design work for second demonstration ▯

WP7 Trial Construction and Operation	SSEN	Construction of the demonstrator and its implementation based on the Detailed Design and Trial Programme. Trial 1 is a physical demonstration of the Primary RaaS while Trial 2 goes to the open market for the RaaS service in an alternative location and forms part of WP6 discussed previously. WP7 will include the following high-level tasks: • Procurement of assets, products and services • Permitting and construction of RaaS and network assets • System integration • Commissioning and testing • Operation, Monitoring and optimisation • Validation and verification of technical and business case assumptions
WP8 Dissemination	Costain & SSEN	WP8 contains all dissemination and documentation for the project as a whole and all work package specific activities.

Figure 14: Work package descriptions.

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RIIO NIC NETWORK INNOVATION COMPETITION

Appendix 4: International Learning

Swedish Microgrid Project, Simris

A review of previous work shows the proposed Project is innovative and provides evidence it has not been tried before.

E.ON's microgrid technical demonstrator at Simris in Sweden. *The Simris microgrid was one of six in the €23m InterFlex project, supported by EC Horizon 2020 funding.*

The Simris project demonstrates the technical viability of rural microgrids and specifically the capability of a battery system to allow seamless transition of a section of medium voltage network to islanded from the grid, operation on 100% renewables only, and subsequent seamlessl reconnect to the network.

E.ON bring the technical understanding and lessons learnt from the Simris technology demonstrator to support the functional specification, design and testing of the SSEN MV demonstrator to support network resilience.

A microgrid provided power to around 150 households, using an industrial battery to store locally-generated wind and solar energy.

Key achievements included:

- Seamlessly disconnecting and reconnecting the microgrid with the main network at the start and end of the trial
- Providing households with continuous energy for several days without reverting to a back-up generator.

However, as a technical demonstrator, Simris did not address the regulatory or market issues with the application of the technologies to supply resilience to parts of the distribution network.

The Raas Project aims to address these issues by breaking down the functional requirements and defining asset ownership boundaries, to give clarity on scope of supply to allow the greatest number of suppliers to enter the market.

The need to undertake technology integration, and define the service at scale to encourage national rollout drives the **NIC funding requirement**. The forecast benefits and net present values for our two rural microgrid demonstrators are contained in the appendices.

Network Revolution Project. This customer-led project provided the design tools DNOs need to calculate local resilience requirements, based on network topology, energy supply and demand.

Other demonstrations of islanding microgrids are small-scale private, industrial, commercial or campus environments, and operate in vertically integrated value chains.

Figure 15 – E.ON's microgrid technical demonstrator at Simris in Sweden

An overview of the Simris system, including all suppliers, is shown in **Figure 16**.

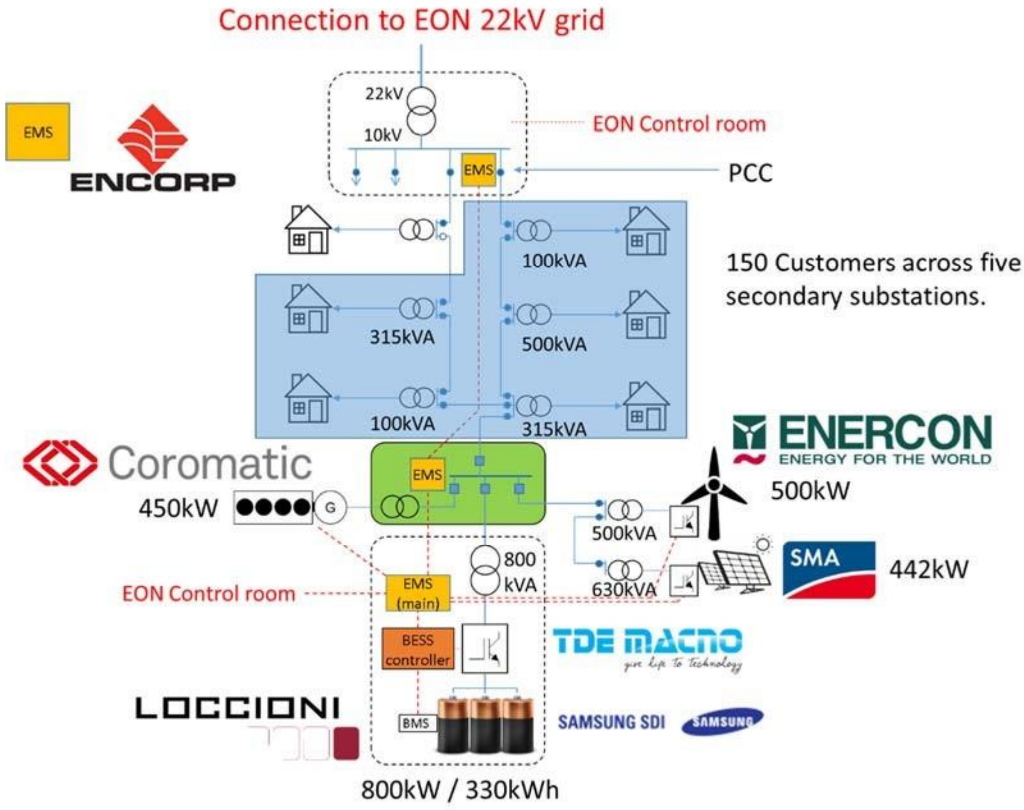

Figure 16 – Overview of key components, sizing and supplier

Applicability to RaaS

Simris approach to transitions

The microgrid in Simris demonstrated seamless transitions between grid-connected and islanded operating modes.

The methodology used for the transitions is: First the EMS sets the BESS to an operating mode as a grid-parallel voltage source, operating in droop for both real power as a function of frequency and reactive power as a function of voltage. The EMS then updates the BESS target voltage and frequency until the real and reactive powers exchanged across the point of network connection is near zero and then opens the circuit breaker, transitioning the system to island operation.

It should be noted that these transitions are designed to be operated in a controlled way only and the approach is not appropriate to the provision of resilience where the outages are not known in advance. Seamless transitions in case of unplanned outages are significantly more challenging.

While it is theoretically possible to have the BESS operate in a mode whereby it can transition to island operations upon loss of grid, this introduces a number of additional technical challenges.

The Simris demonstrator is capable of black-start operation from the BESS only, which has been tested for a small section of network but has not been tested with customers supply.

Simris approach to earthing
The BESS transformer is a delta winding, and when islanded from the grid and operating from the BESS only, the 10kV system is run with no earth reference.

In the event of an earth fault, open-delta measurement transformers will detect the common-mode voltage and disconnect the renewable generation and BESS sources, resulting in a temporary outage. The network should then be manually reconnected to the network.

It is expected that for the RaaS project, the 11kV section will need to have an impedance earth reference when islanded, through the controlled switching of an impedance between the transformer star point and earth or through a switched zig-zag transformer or similar.

Simris approach to protection
The over-current protection in the Simris LV network is based on use of fuses. The BESS system is capable of delivering significantly lower fault current than the grid, so clearing fuses is a technical challenge. The approach to protection for Simris was to specify the BESS to clear fuses up 63Amp fuses at 400V and be capable of subsequently recovering the 10kV system. This has been tested for single-phase and three-phase faults both in isolation and operating in parallel with other generation sources. In all cases, the fuses were cleared, and the voltage restored within 150ms.

For larger fuses, the BESS may not be capable of delivering sufficient fault current to operate the fuse in an acceptable time. To guarantee safe operation for faults that the BESS is unable to clear, the new substation (green element in **Figure 16**) includes protection relays with two different sets of protection settings. When islanded, the protection relay controlling the circuit breaker connecting the generation sources to the customers will trip at significantly lower current than when grid-connected. In the event of a fault that the BESS can not clear, the protection relay will trip the circuit breaker, so that there is no danger of the battery delivering prolonged fault current.

For the RaaS project, a similar approach to the protection system should be adopted and documented. The BESS system should be specified and tested to be capable of operating protection to an agreed level when islanded, and if the limited fault current from the BESS is insufficient to clear the fault then additional protection relays should detect the over-current and trip the BESS supply.

Simris approach to DNO integration
The Energy Management System in Simris interfaces to a dedicated RTU that communicates a limited number of key parameters to the E.ON Energidistribution AB control room scada. This includes the battery system power and state of charge and the backup generator fuel tank levels.

The powers across all circuit breakers in the Simris MV network are monitored and logged by the control room scada system.
For the Raas project, the BESS must interface to both an aggregator in addition to the DNO interface.

Simris approach to renewable integration

In Simris, the EMS has been physically installed in the battery container, with a direct cabled communication to the battery system. On site, all of the data links between the assets have been implemented using fibre optic connections. This includes:

- EMS to other measurement and control equipment in other substations
- EMS to ind turbine EMS to solar generation EMS to backup generator.

While directly-connected fibre-optic connection provides a reliable connection, trenching fibre optic between assets is expensive, particularly over long distances.

Connecting the provision of resilience directly to the primary substation minimises the cost of the communication between devices.

If additional renewable systems are included in the scope of the RaaS project, alternative communication methods should be considered, such as a mobile data link. This will be particularly valuable where data is not time critical, such as renewable curtailment where the time constants are potentially several minutes.

Results from the Simris demonstration

The E.ON microgrid at Simris has shown that it is possible to operate a BESS in such a way that allows an MV circuit to seamlessly transition from grid-connected to islanded, to operate with the voltage (amplitude, frequency and THD) within statutory limits when islanded, and to subsequently resynchronise and seamlessly reconnect to the grid.

This has been tested over several weeks of operation through 2018 and 2019 and has given valuable insight into how a microgrid can operate.

The demonstration highlighted a number of technical challenges which have not been addressed in the project.

One important technical element that was not demonstrated in Simris was the ability of the system to detect grid health and auto-island in case of grid fault. The reason that this was not implemented is that if the battery system is operating as a grid-parallel voltage source capable of islanding at all times then the location of an upstream fault can not be easily determined and the BESS may attempt to island additional circuits in parallel with the intended circuit.

The provision of resilience can be realised in several different ways, with the simplest being to allow a temporary outage, isolate the circuit breaker at the point of network connection and then black-start the network from the BESS.

Other International Resilience Microgrid Projects

Navigant Research are a well-known market research and advisory firm that tracks microgrid projects. The company has identified over 4,700 microgrid projects around the world, which constitutes around 30 GW of generation capacity [9]. However, in contrast to the proposed resilience as a service project (RaaS Project), some of them do not primarily address resilience. Examples are the Brooklyn Microgrid [10], which instead addresses microgrid-like market models for energy transactions. Another example is the Issygrid project in France [11], which optimises energy consumption across a district.

Key examples of projects with a focus on resilience are presented below.

Sendai Microgrid, Japan

The Sendai Microgrid at Tohoku Fukushi University was amongst the first microgrids to demonstrate resilience in a real-world environment [12]. Although the microgrid used primarily fossil fuel to provide resilience (gas engines, fuel cell and some solar PV), it demonstrated the ability to provide resilience when power networks fail, particularly to maintain critical services such as heat. The project also showed that for extended resilience provision, microgrids benefit from diversity of power supply, and that flexibility against demand is supported by diversity of energy storage. The project also showed that the right operational relationships must be in place for successful islanded mode operation. This latter incremental learning is highly relevant to the RaaS Project; RaaS commercial arrangements must provide the right incentives for the initial investment and during operations, and therefore must detail failure modes the RaaS solution should/should not cover.

Graciosa Microgrid, Azores

Many microgrid projects have been implemented in remote areas with no electricity network, for example remote military bases, mines or remote communities. One such project is the Graciosa Microgrid project in the Azores. The system is similar in scale to the proposed RaaS Project concept. It uses a 2.8 MW battery along with associated systems to stabilise an islanded network. The system is operated without the benefit of conventional rotating plant inertia, and 65% of the island’s energy comes from variable renewables.

A key benefit of this project is the reduction in fossil fuel consumption, since higher fuel costs in remote areas and the reliance on diesel leads to higher electricity costs for consumers. Like Simris, this project shows an islanded microgrid can use storage to balance renewable supply and demand without using the inertia of rotating plant, potentially indefinitely given sufficient supply and storage. However, there are two important differences with the RaaS Project. Firstly, from a technical perspective, microgrids such as Graciosa do not have to manage the process of disconnecting and reconnecting to a larger network. Secondly, the RaaS Project exists in a different commercial and regulatory context; in Graciosa, the resilience provided by storage is part of day-to-day operations. In contrast, the RaaS project business case will be based

[9] https://microgridknowledge.com/microgrid-tracker-rise-asia-pacific/
[10] https://www.brooklyn.energy/
[11] https://www.enedis.fr/issygrid-0
[12] https://www.smart-japan.org/english/vcms_cf/files/The_Operational_Experience_of_Sendai_Microgrid_in_the_Aftermath_of_the_Devastating_Earthquake_A_Case_Study.pdf

on providing resilience as a standby service. Also, grid-connected solutions such as the RaaS Project have different economic drivers to the Graciosa Microgrid; the cost of delivering fuel to these sites in which traditional networks are absent means the driver is to reduce fuel consumption without compromising the resilience historically delivered mainly by diesel generators. Therefore, apart from deployment scale, the relevance of the Graciosa Microgrid to the RaaS Project is low.

Military Microgrids, USA

The US military has also been an early-adopter of resilient microgrids, with a target of 14 days off-grid resilience for its sites [13]. Their projects are exemplars of microgrid projects delivered in private-wire campus environments e.g. educational, industrial and military; renewable energy generation is used both in grid-connected and islanded modes to reduce fossil fuel consumption.

Military microgrids are clearly similar to the proposed RaaS Project in the ability to maintain supply to end-users if the wider network fails. Also, the capability to run independently for 14 days would, in a GB context, provide ample time for service restoration. However, like all private wire systems, there do not appear to be any specific RaaS contracts that are activated upon a grid fault. A particularly advanced military microgrid has been constructed at Otis Air Force Base [14]. Like Simris, it shows that a grid-connected microgrid is capable of extended, low-carbon islanded operation subject to availability of renewable generation. Also like Simris, the microgrid shows that during islanded mode, if adverse weather conditions lead to insufficient renewable generation, conventional generation is required to provide extended resilience. This remains an important consideration for RaaS solution design parameters.

Denver Airport Microgrid, USA

The installation at Denver airport is an example of stacking revenues from microgrid storage assets. Aggreko, a UK supplier of temporary power generation equipment, deployed a 1 MW battery storage system at Denver Airport [15]. In addition to providing resilience for an airport building, the solution optimises use of a 1.3 MW solar photovoltaic array to reduce energy costs and manage constraints on the grid feeder cable. This microgrid therefore shows the possibilities of 'value stacking' resilience with other opportunities.

Monash University, Clayton, Australia

Installation of a fully functional Microgrid solution in Australia's, Monash University. One key problem with integrating renewable energy like wind and solar is its flexibility, which poses challenges where powering critical facilities like hospitals and data centres is concerned. Microgrids have provided a reliable solution to supporting the universities energy needs allowing the campus to run on almost exclusively on renewable energy sources. With their ability to stand apart from main grids, these 'energy islands' can

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[13] http://microgridprojects.com/military-microgrid-army-navy-air-force-microgridsdrivers/
[14] https://cleantechnica.com/2018/09/10/otis-microgrid-cape-cod-military-base-to-runfully-on-renewable-energy/
[15] https://microgridknowledge.com/xcel-panasonic-and-denver-airport-to-team-on-103m-solar-microgrid/

store and feedback green power into the network, greatly improving grid reliability - and costs as well.

Monash University is tapping this technology in a ground-breaking trial with the aim to run its Clayton campus on 100% renewable energy - generated and stored on-site. The campus will combine a variety of distributed energy resources including up to 1MW of rooftop solar, 20 automated energy management systems, 1MWh of battery storage and more, forming a microgrid that will generate 7GWH of energy - enough to power 1,000 Victorian homes for a year - by 2020. Given the significant amount of power universities consume during the day, such microgrids provide a clean, effective way for campuses to take control of their own energy usage.

This work is relevant to the proposed RaaS Project, as the Project Team believes the business case in a GB context for establishing the storage element of RaaS is likely to be driven by stacking revenues from multiple market opportunities. The Project will develop the business model for the GB context and will therefore understand the interaction of RaaS provision with other parts of the market, such as those run by National Grid ESO, DSO constraint management, and energy retail markets.

'Microgrids typically need to make a business case for their primary value proposition: resilience', Navigant Consulting, March 2019.

The above international projects and many others demonstrate the technical viability of delivering resilience using microgrids. The projects also show there can be a strong business case, particularly in private wire environments; 'Energy-as-a-Service' (a form of power purchase agreement between a campus consumer and energy asset provider) is increasingly favoured by campuses that do not want to invest in or operate onsite microgrids. That said, the USA microgrid market appears to be the most commercially developed. However, Navigant Consulting noted as recently as March 2019 that: *'microgrids typically need to make a business case for their primary value proposition: resilience'* [16]. This situation is clearly true for Great Britain.

Therefore, the key RaaS Project value-add will be development of a suitable commercial model. This will stimulate competitive market investment in the provision of resilience to support DNOs in delivering improved electricity supply to their customers. A rigorous, market-based valuation of RaaS will therefore enable further development of smart grid business models that facilitate the increased uptake of low-carbon energy.

Appendix 5: Smart Grid Transition

Strategic Direction

The RaaS project proposes to take strategic direction during the delivery phase from the ENA Open Networks Project. This will ensure the solution complements the wider DSO transition activities and concentrates on the communities most likely to be left behind during the Smart Grid transition. Engagement with the ENA Open Networks Project also facilitates effective coordination with other industry trials, in particular National Grid ESO's Black Start Project with SP Energy Networks.

[16] https://www.navigantresearch.com/news-and-views/unpacking-the-value-ofresiliency-that-microgrids-offer

The ENA Open Networks Project also believes that stakeholder input is critical. The team have worked to involve anyone who has any interaction with the networks in Great Britain, across the whole energy system. A representative Advisory Group has been created containing approximately 40 experts from across the GB energy industry including: suppliers; aggregators; IDNOs; industry groups; academia; Generators; consumer groups; the gas industry; Government; Ofgem and other industry parties. ENA and its members have used the Advisory Group, which meets bimonthly, to inform stakeholders of project progress, but more importantly allow contribution and input to the workstream products at a very early stage. All this input and feedback has strongly shaped the outcome of products and the 2019 work plan which now includes a workstream focused on Planning and Forecasting.

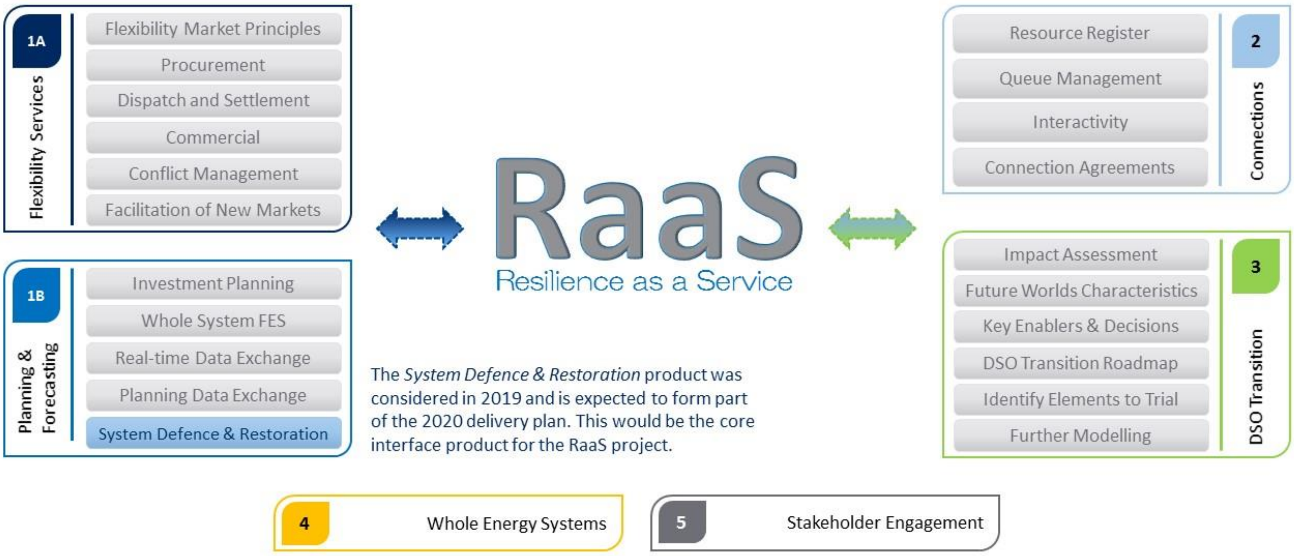


Figure 17 – Resilience as a Service interaction with ENA Open Networks Project.

While all workstreams will have visibility of the RaaS outputs, the Planning and Forecasting workstream is expected to be the core point of engagement for the duration of both projects. The workstream has been shaped by the Advisory group, and public consultation feedback on the Future Worlds and Least Regrets Analysis. The deliverables consolidate findings from industry trials and progress changes to facilitate the transition to a smart grid architecture. System Defence and Restoration was a product discussed during the 2019 scoping phase and pencilled-in for progression in 2020, after some of the other products and industry trials had established foundations upon which the proposed product could build. The RaaS Primary method presented in Section 2 would be a timely addition in 2020, being carefully designed to leverage existing learning and build a demonstrator complimentary to the upstream restoration work scoped by National Grid ESO and SP Energy Networks for their Black Start project. Initial talks with the existing demonstrator team highlight an opportunity for coordination through Workstream 1B of the ENA Open Networks Project and will be integrated into the Open Networks Project scoping sessions in the final quarter of 2019.

Core Enablers

The RaaS project is a timely addition to the GB innovation projects portfolio, facilitated by a number of forerunner projects that have removed traditional technological and commercial barriers. The resulting core enablers allow the RaaS project to focus scope and funds on the reduction or deferral of costly future network reinforcements, and minimising the use of carbon intensive standby generation needed to provide a secure electricity supply.

Flexibility Services

SSEN is an industry pioneer in DSO services, with the CMZ scheme implemented in BAU in 2016 to attempt to secure load injection or demand reduction services to offset the need for network reinforcement. Since its inception other DNO's have followed suit, developing their own versions of CMZ and now developing a wider array of service types. The wide uptake of CMZ style services is a response to a generic shift within UK DNO's towards the utilisation of flexibly connected and controllable Distributed Energy Resources (DER), the works undertaken through the ENA Open Networks Project and a commitment made on behalf of those DNO's by the Energy Networks Association (ENA) to the Department for Business, Energy and Industrial Strategy (BEIS) in 2018.

To ensure SSEN remains a lead supporter for encouraging and supporting the evolving network services market, while looking to a wider set of network issues which can be managed or avoided through the use of network services, a suite of services have been developed. Yet for such services to be successful there needs to be a market which today is in its infancy. DSO demonstrators such as TRANSITION, EFFS, FUSION and Power Potential all support development of such markets, but customers in more rural and electrically isolated areas may be unable to engage and be left behind in the move to a Smart Grid architecture. This project will include development, demonstration and trialling of an economically viable, scalable and replicable technical and commercial solution to ensure no stakeholder groups are left behind during the transition to a Low Carbon Economy.

Operational Tripping Schemes

SSEN must ensure that if there are two circuits running in parallel and a circuit fails then the other must accommodate the load. This forms part of system planning standards. A generator may incur additional reinforcement charges due to the remaining circuit not having a sufficient excess capacity. Therefore, an intertrip connection may be offered. This allows a customer to connect onto the network under the condition that the generator will be disconnected from the network if a circuit fails.

Active Network Management

Active Network Management (ANM) systems link separate components of a smart grid such as smaller energy generators, renewable generation and storage devices, by implementing software to monitor and control the operation of these devices.

SSEN pioneered the development and deployment of ANM through innovation projects to develop Britain's first smart grid on Orkney. A review of the Orkney ANM scheme identified a solution cost of £500k compared to the £30m alternative reinforcement cost.

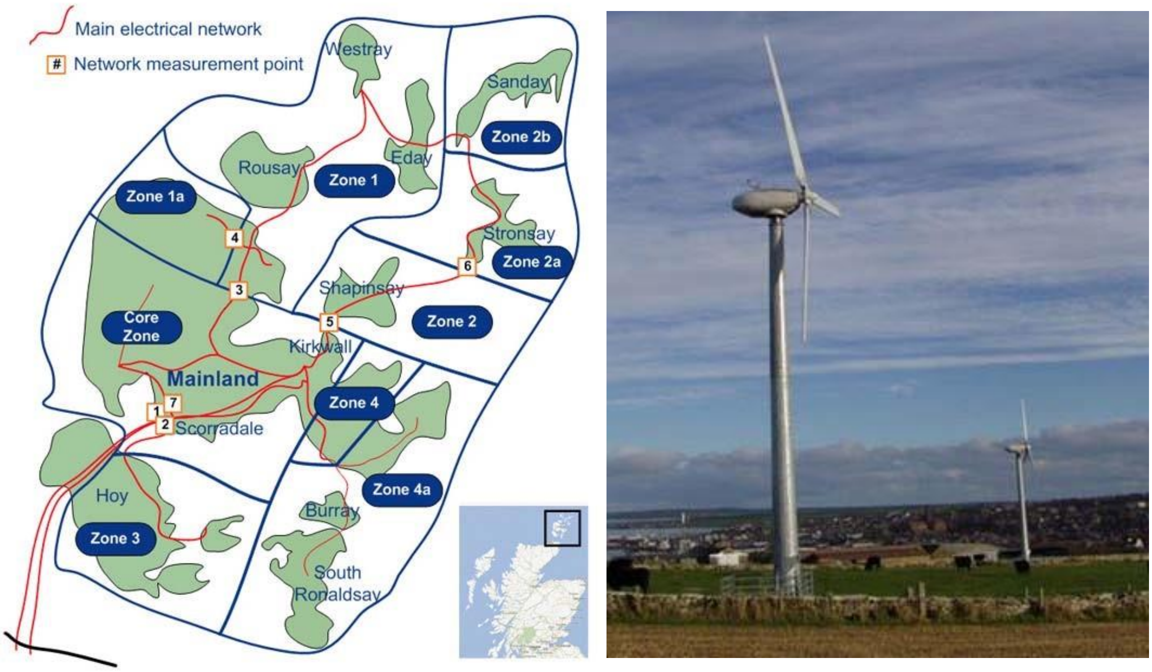


Figure 18: Orkney Active Network Management

Active Network Management (ANM) systems can be potentially implemented in areas where there are several, complex thermal constraints on our network affecting a number of customers over a long period of time. The ANM systems continually monitor all the constraints on the network in real time and allocate the maximum amount of capacity available to customers in that area based on the date their connection was accepted. ANM technology and operational procedures have developed over recent years, now enabling other concepts such as the RaaS Primary method to be explored.

Appendix 6: Trial Objectives and Operation

Trial Objectives

The trials for medium voltage (MV) resilience on the SSEN network will be demonstrating a combination of technical and commercial issues to the provision of resilience. The commercial element includes developing an understanding of the cost and implications of delivering, installing and operating the BESS system, balancing the conflicting requirements of using the BESS energy for resilience and maintaining sufficient energy for resilience when needed.

The technical demonstration of the provision of resilience should include disconnecting the section of network from the grid and verifying that the RaaS system can:

- Detect the outage
- Take all of the required actions to restore power to the islanded network in a controlled manner
- Operate the 11kV network in a stable way from the combination of BESS and any renewable generation in the network for a period
- Communicate system status effectively with the SSEN control room.

During islanded operation, fault response of the system should be tested by introducing controlled faults on the LV network

On return of the network voltage, the RaaS system should:

- Detect that the supply has returned
- Take the required action to return the island to network connected in a controlled manner
- Return to being controlled to operate in other commercial markets.

Trial Operation

The trial methods, technologies and physical architecture of the medium voltage RaaS demonstrations on the SSEN network are expected to follow the microgrid demonstration at Simris, Sweden. In addition, we will focus on optimising resilience against unplanned outages whilst facilitating opportunities for RaaS providers to generate additional revenues from other markets, which will reduce the overall cost for network customers

A Battery Energy Storage System (BESS) is expected to be the primary storage technology to act as the voltage source needed to provide resilience and will be connected to the SSEN network at 11kV. This will be combined with appropriate energy management systems, to manage power flows and network stability, and include integration of locally connected renewables. Factors affecting the BESS technical specification include requirements for network power, resiliency duration, available capacity at the point of network and access to additional revenue streams to provide other resilience services. A headline BESS specification of around 3MW/3MWh is proposed for the trial, which will cover over 90% of three-hour duration outages. The trials will be structured to allow a range of fault and network scenarios to be demonstrated and / or simulated.

The detailed design objectives will be agreed during the first phase of the RaaS project which will shape RaaS functionality. The simplest approach for long outages is to allow a short network outage (10 seconds) whilst the section of network is isolated from the grid, then effect a black-start using the RaaS equipment. This approach impacts the BESS specification, which must be able to run in two distinct modes each with different earthing arrangements i.e. as a controlled real and reactive power source when grid-connected, and as a voltage source when islanded. As the BESS is expected to comprise several discrete but co-ordinated battery systems, controlled power sharing between the BESS systems will be specified.

From a network operation perspective, an approach to the safety case, earthing arrangement and response to failure will be agreed and documented, in a manner similar to the demonstrator at Simris. The BESS will be capable of significantly lower fault current than the grid connection, and the maximum fuse rating for the BESS will be agreed with SSEN. This will result in an electric current and duration requirement for the BESS, potentially along with a requirement to change fuses for protection relays with two distinct settings. Again, this will be determined during the detailed design work in the first phase of the Project.

The simplest approach to black-starting the network following an outage would be to demand full voltage and allow the BESS electronics to operate against the current limit. However, this must be coordinated with the protection scheme so that the system does not ‘trip’ because of an over-current or under-voltage during energisation.

The optimum physical location for the BESS is at the primary substation. This will allow direct hard-wired communication between the BESS and the circuit breaker whilst avoiding the expensive trenching needed to deploy new fibre-optic cables. The BESS will interface at 11kV, and the scope of supply for the medium voltage transformer will be agreed.

The interface requirements to the DNO control room (potentially through an ANM supplier) and any other market participants will then be defined, along with the data that needs to be communicated. After the control functions and interface requirements are understood, a decision will be made on the division of scope of supply for the control system i.e. whether an independent energy management system is required, or whether the BESS supplier can integrate the functions into its local controller.

Appendix 7: Demonstrators

The trial site shall be selected through adaptation and application of the Site Selection Methodology developed by another NIC funded project, TRANSITION. The selection shall target communities most at risk of being left behind during the low carbon transition due to the remote nature of their location and or limited network resilience following the application of a Smart Grid architecture. The RaaS project focuses scope and funds on the reduction or deferral of costly future network reinforcements and use of carbon intensive standby generation needed to provide a secure electricity supply.

The partners have held workshops to begin discussions on RaaS technical and commercial service parameters to be explored during the Project, considering a wide range of questions which the answers to which should inform the Site Selection Methodology adaptation, ensuring the demonstrator site is representative while having the characteristics needed to maximise learning and validate in project decisions. Initial scoping considered a wide range of parameters including:

- **System dimensioning.** How should the system be rated to cover forecast peak demand at any time and how should the system behave when the peak demand is greater than the supply capability of the microgrid?
- **Microgrid availability.** How should RaaS availability requirements be defied - statically or dynamically?

- **Balance of availability and usage payments.** What should be the payment regime be structured between availability and usage payments from the DNO to the RaaS provider?
- **Commercial relationships.** How should they operate when RaaS providers, who operates the energy management systems, BESS interact with local renewable generators within the microgrid, or 3rd party demandside response providers?
- **Service provided upon network failure.** Should RaaS provide a seamless transition to islanded mode, or a 'black start' of the microgrid? Refer to **Figure 32**.

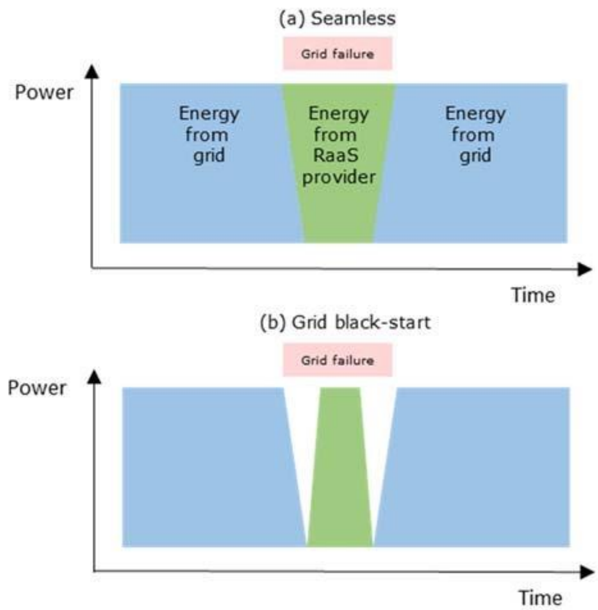


Figure 19: Service provided upon network failure options

The workshops provide evidence of the concept development work undertaken and the Project's readiness to start.

The Site Selection Methodology shall be applied during WP2, Front-End Engineering Design (FEED), to ensure we select the optimum sight for the demonstrator. However, an initial investigation combined with the Cost Benefit Analysis conducted by consultancy TNEI provides several sample cases where the method would be applicable. Three of these have been used to build up the project costs, ensuring the demonstrator is able to fully develop and test the method, facilitating timely roll out to applicable GB sites with minimum disruption to customers. [redacted]

[redacted] *Section redacted* [redacted]

Appendix 8: Investment Case for Service Providers

Resilience Market

The Project will establish the processes to support the commercial scalability of Resilience as a Service (RaaS) for DNOs. To enable scalability, the perspective of an investor in the assets that provide RaaS must be considered. They must make a significant up-front investment, with income thereafter comprising an annual fee for the resilience service they provide. In order for an investor to enter the market they must have clarity on the financial return.

It is likely that resilience demand alone will not cover the cost of the assets, particularly the battery. Instead additional revenue streams from flexibility are needed to strengthen the service provider business case. This will reduce the cost of resilience to DNOs and make RaaS systems less costly than traditional resilience alternatives. However, external revenue streams are linked to volatile markets. This may result in a wide variation in RaaS fees between service providers, as they may form different views on future market developments and perceived risk. This is illustrated by the calculation presented below showing target return rates based on perceived risk (investor market trust).

Since the goal is to provide resilience at the lowest possible cost for the end customer, all factors influencing the RaaS fee must be addressed. Both trust in the market and barriers to entry are key factors, and will be addressed by this Project by standardising supply chain engagement for all GB DNOs. Without this Project, these issues will be ignored and multiple different market arrangements will emerge. This will lead to a small number of participants in each market, weak competition and high RaaS fees. Ultimately, there will likely be few economically viable RaaS cases for DNOs and investors.

Figure 36 below presents an exemplar investor business case assuming a mature market in which a ten year RaaS application is possible due to a high level of standardization. Three levels of trust (described above) in future market development illustrate the impact on the RaaS fee.

Base assumptions are:

1 MW RaaS system

- RaaS system cost: 750,000 GBP RaaS operational cost: 2% p.a.
- RaaS contract duration: 10 years (potentially multiple subsequent contracts)
   Annual flexibility revenues (post marketing cost): 60,000 GBP/MW/a
   Inflation: 2% p.a.
- Tax Rate: 17%.

Investor Market Trust	Target IRR	Static Payback	Required RaaS Fee [£/MW/a]
Positive	10%	7 Years	£ 76.745
Neutral	15%	6 Years	£ 108.525
Negative	20%	5 Years	£ 143.068

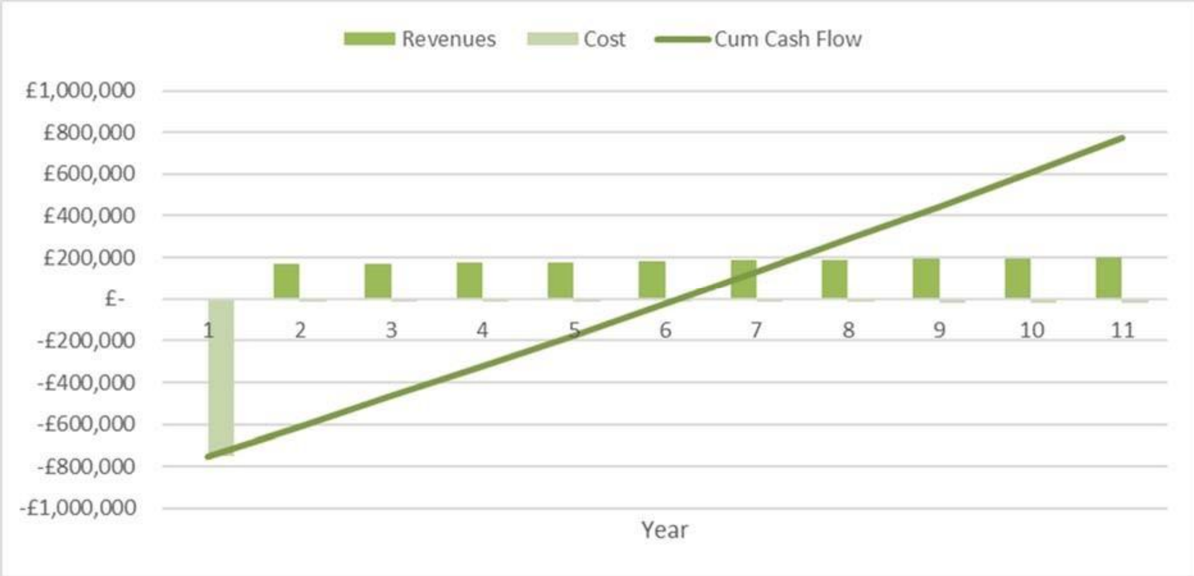


Figure 20: Revenues, cost and cash flow for a neutral investor (IRR expectation of 15%).

This shows how an investor's target IRR has a significant impact on the RaaS fee. An increase in IRR of 5%, that is, from the 10% to 15% IRR case, results in customers paying an extra £3 million over 10 years in a low resilience 10 MW network. Therefore, the standardization enabled by this Project will be key to decrease the perceived investor risk, RaaS Fee and cost to the end customer.

Other markets

From an investor perspective, this Project is not only key to opening the UK market for RaaS, but also provides a chance to develop solutions that can feed back into other markets to start similar initiatives.

Many potential sites can be identified at which RaaS can be applied in different European countries with their respective grid infrastructure. However, the barriers that exist in the UK might also impede development of RaaS services in these countries. If this Project enables a mature market to develop in GB, learnings and experiences can be transferred from investors and RaaS Providers into other countries. This will establish a positive feedback loop to improve products, solutions and services, realise economies of scale, and reduce the cost of resilience for GB RaaS customers.

Appendix 9: Supply Chain Engagement

E.ON's demonstrator at Simris, Sweden and other microgrid projects (described in Appendix C) prove the technical viability of providing resilience using batteries and renewable generation.

Ensuring RaaS becomes business as usual

To ensure RaaS demonstrators become 'business as usual' for DNOs requires many issues to be overcome, such as:

- **Variability in procurement processes between DNOs**. This impedes supplier's ability to scaleup and reduce cost through RaaS solution standardisation.
- **Ineffective information flows to the supply and investment community.** Without the right information, suppliers are likely to create solutions which do not meet buyer requirements; in contrast, overly prescribed engineering requirements reduce supplier's scope for innovation.
- **Lack of clarity on key commercial risks and addressible market.** Market entrants need information on risks and opportunity size to inform their investment decisions, make the market attractive and gain their commitment.
- **Only early movers develop the required skill sets leading to an uncompetitive marketplace.** Initial innovators should retain a competitive advantage in the market they create. However, to reduce costs for the customer healthy competition must evolve.

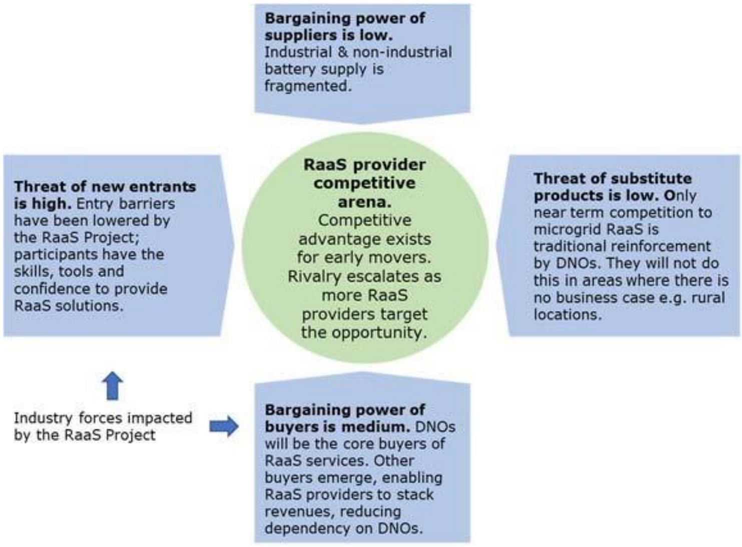


Figure 21: Industry forces upon Project completion.

The Project will lower entry barriers to the RaaS service provider arena. The core buyers are DNOs but other buyers will allow service providers to stack revenues and establish a strong business case. Costain will act as an independent body with the intent of ensuring a fair, transparent and competitive arena for RaaS.

The attractiveness of a market and intensity of competition can be determined by analyzing the (five) key forces acting on the industry (**Figure 21**). This shows how the Project will increase the threat of new entrants by lowering entry barriers (by addressing the issues described above) and reducing the dependence on DNOs as sole buyers.

To maximise customer value, the team believe the Project must develop a clear route to market, in addition to providing a successful technology demonstration. Hence WP4Operational Optimisation and WP5-Business Model will provide insight into commercial operations of a RaaS solution and commercial arrangements, respectively. However, this alone will not ensure a rapid uptake of RaaS services.

Therefore, WP8-Dissemination has been designed to help enable DNOs engage in RaaS procurement, whilst WP6-Supply Chain & Engagement will accelerate the development of the service provider and supplier community. WP6 helps manage the risk that at the end of the Project, only the partners have the know-how to procure, price and deliver RaaS solutions with confidence. Instead, this knowledge will be available to the entire supply chain.

Maximising customer value through the new Institute for Civil Engineers PROJECT 13 infrastructure delivery model

In all major projects since 2017 and in bringing new technologies to market, Costain has applied the philosophy and methodology of ICE Project 13. We will apply this to the RaaS Project to realise a sustainable, innovative, value-for-money method for delivering RaaS to the GB customer.

Project 13 moves away from the traditional transactional model where at each point in the value chain the supplier with the lowest price typically wins a bidding competition for a contract which lays out detailed requirements. In the new model, members of the value chain from investor to supplier are treated as a single enterprise aligned by a single definition of value to the customer (end user). Therefore, each member is commercially incentivised to pursue a common goal. Costain are encouraging HS2 to adopt this approach and aligning all parties to unlock economic growth (the intended value generated) through all contracts; this is expected to boost the UK economy by £15bn every year.

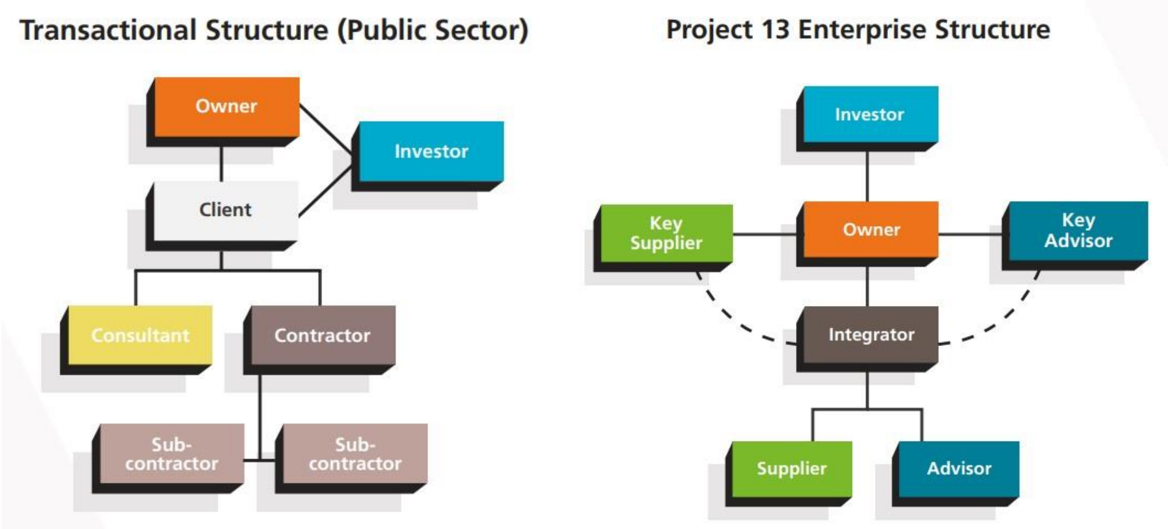


Figure 22: Traditional and new Project 13 delivery structures.

The GB RaaS market comprises a multi-party system where risks, roles and wider system implications are undefined; RaaS commercialisation is therefore a prime candidate for the Project 13 philosophy. By embedding P13 principles into the RaaS value chain from the outset, the resulting commercial approach, procurement activities and supplier involvement will result in lower costs and much more value-adding RaaS for the customer.

Accelerating RaaS market development by ensuring all DNOs and other participants have the skills, tools and confidence to procure or provide RaaS solutions

This will be achieved through **WP6-Supply Chain & Engagement**. This comprises three stages, as follows:

Stage 1: Create a system commercial model to apportion risks. We will undertake a **commercial risk analysis** to establish the commercial characteristics and interoperability of the various parties. Stage 1 will also set out a standard commercial methodology. We will achieve the above using the technical requirements compiled in WP2 Front-End Engineering Design, and the verified business model and contractual terms agreed in WP 4 Operational Optimisation and WP 5: Business Model.

To minimise system costs, we will allocate risks to the party best placed to manage and price risk. For example, if a party encounters a risk which it cannot easily manage, the service cost will likely increase disproportionately to the real risk level. Accurately understanding, mitigating and disseminating commercial risks will therefore influence the behaviours, investment and commitment of RaaS suppliers.

In accordance with Project 13 principles, understanding the right level of information to inform the supply chain will also reduce the overall cost of RaaS. This is because suppliers will be given sufficient flexibility to propose solutions which align with the enterprise value. This is evident in Costain's work for Shell; in identifying their valueadding activities in the supply chain, we reduced engineering requirements by 85% resulting in a capex saving of $200,000.

Stage 2: Supply chain mapping. To better understand supplier capabilities, we will disseminate the results of our investigation into the optimum RaaS value chain. This will include categorised supply chain skillsets and limitations, which will then be mapped against the system requirements model developed in the stage 1.We will also investigate the initial TNEI's Section 3 to confirm of the size of the RaaS opportunity. By mapping supply chain skillsets, the RaaS project can validate the learning outcomes of WP 4 Operational Optimisation & WP 5 Business Model against common market skill sets, thereby creating a more inclusive, competitive marketplace for RaaS. This will also mitigate market dominance of first mover RaaS suppliers and identify supplier lock-in mechanisms. Understanding supply chain skillsets will inform the procurement strategy and allow standardization of procurement processes across distribution network operators, which will increase RaaS solution scalability.

Stage 3: Prepare the supply chain for response to tender: We will inform, engage and consult on behalf of the client, investor and supplier organisations to drive commitment to contributing fairly to the market. If the concept is proved technically and commercially during WP 5 - Business Model & WP 7 - Trials Construction and Operation, stage 3 will move the RaaS solution into BAU by running a full feasibility and procurement exercise in collaboration with SSEN for a second demonstrator area. This will test our commercial strategy and determine if the transition of RaaS to BAU has been successful. The second demonstrator deployment will seek funding from BAU.

This will test the market readiness and prove to other GB DNOs that if the standard methodology is followed, RaaS can be procured at a competitive rate versus traditional network upgrades.

Ensuring extensive involvement of all stakeholders is a fundamental element of Project 13; this will help create a more effective market in aligning all participants to the agreed RaaS value statement. Throughout the consultation, we will seek opportunities to remove barriers to entry and stimulate healthy competition. The Project will also gain better engagement from market participants which will further encourage investment and innovation.

In undertaking the activities in WP6 - Supply Chain & Engagement, we will be able to:

- Publish the commercial strategy on the SSEN RaaS webpage.
- Open a consultation for supplier engagement on the SSEN RaaS webpage.
- Publish consultation results and market testing findings on the SSEN RaaS webpage .
- Produce a report outlining details of the proposed business as usual application of the method.

At this stage, we will have created a standard flexibility procurement mechanism agreed by the third-party investment community, the supply chain and GB network and system operators (via mandatory dissemination to the ENA community). As described above, the effectiveness of our approach will be confirmed by the WP6 procurement exercise.

The importance of 3rd party ownership: reducing the cost of RaaS for DNOs and customers

Studies have shown that resilience demand alone will not adequately cover the cost of the battery used in the Primary RaaS method. Instead, a model is required whereby a third party owns the battery and supplements resilience income with additional revenue streams – this is the Value Stack model proposed in WP5 - Business Model. The approach will result in lower costs to DNOs and its customers.

Engaging the market will also encourage innovation and creativity; the market has achieved many step changes in network supply efficiency resulting in greater resilience, flexibility, safety, and a lower cost for the customer. For example, through the Contracts for Difference framework in the offshore wind industry, the market has reduced the cost per MWh by around 50% by achieving the correct balance of 'investability' and reward for offshore wind operators.

A key risk is that supplier lock-in mechanisms along with excessive involvement with a single supplier will lead to a lack of competition. We have mitigated this by positioning Costain as market adjudicators; they are well-placed to do this through their strong portfolio of procuring UK's infrastructure on behalf of the GB tax payer. Costain will preclude themselves from supplying RaaS, and will therefore act as a wholly independent body. Their intent will be to develop a fair, transparent and competitive marketplace for RaaS.

Appendix 10: Project Governance

The project organisation chart in **Figure 23** identifies Project arrangements for management, governance and decision-making. The respective roles and responsibilities of each partner are detailed below.

Project Roles

A risk identified in previous collaborative innovation projects is slow decision-making due to overly large steering groups that are poorly engaged and lack an understanding of Project issues - compounded by the difficulty in setting-up meetings and teleconferences. The Project will manage these risks by clearly identifying and communicating the roles and responsibilities of each party. This will avoid unnecessary consultation and slow decision-making, whilst relying on a smaller group of more focused advisors in the Project Advisory Group (PAG) and decision-makers in the Project Steering Board (PSB).

Stakeholder Advisory Group

The Stakeholder Advisory Group (SAG) will provide strategic oversight, ensuring the Project:

- Remains relevant to strategic direction of the GB electricity sector
- Considers relevant learnings from other innovation projects
- Flexes according to changes in regulation and to new market trends Delivers learning outcomes relevant to all GB DNOs.

The make-up of the SAG consists of regulatory, ENA and key stakeholder members. The NIA Microresilience Project and the NIC Project Black Start from DER are important developments in the evolution in the immature RaaS Market, thus NPg, NG ESO and SPEN will sit on the SAG. This will also help ensure a RaaS market develops that is both technology agnostic and scalable across GB.

Project Steering Board

The Project Steering Board (PSB) will provide direction and decision-making to the project. It will:

- Make decisions escalated by the Project Manager through the change management process.
- Resolve disputes that may arise between the Project Partners.
- Arbitrate between competing stakeholder interests.
- Ensure provision of relevant information and recommendations to Ofgem, where the Project enters a period of formal change control, and where Ofgem expects to influence or provide direction to the Project.
- Ensure Project Deliverables are of high quality before submission to Ofgem.

The PSB comprises representatives from each partner organisation, ensuring a balanced view of the Project at all times. Clearly defined communication channels within the Project, and internal organisational processes, will keep the PSB members well-informed on Project progress. This will ensure they make the right decisions to ensure the intended learning outcomes are realised.

Project Manager

The Project Manager will be responsible for the day-to-day running of the Project by leading WP1 – Project Co-ordination, and decision-making where the impact does not materially change scope, objectives and deliverables of the Project. The Project Manager:

- Ensures the Project is run to time, cost, scope and quality
- Is responsible for enacting the change process on significant scope changes and takes decisions in collaboration with the project partners escalated to him by WP leaders
- Keeps the PSB informed of the project progress through regular reporting and ad-hoc updates as appropriate
- Manages the production of regular Project Reports and Deliverables delivered to Ofgem.

Costain will provide overall Project Management for the Project. However, all partners will support project management, including technical assurance.

Work Package Owners

Work Package Owners lead each of the main work packages 2-8. This will involve:

- Taking decisions that do not have the potential to materially impact other WPs, or the Project as a whole
- Delivering the scope of their WP to time, cost and quality
- Escalating issues, risks and decisions to the Project Manager
- Liaising with other WP owners, keeping them and the Project Manager informed of relevant developments
- Ensuring the learnings from their WP are properly captured, and facilitating learning dissemination during WP8 – Dissemination.

The Change Process

In enacting strong project governance, Costain will implement change control in accordance with following processes:

- A change is identified by either the Project Manager or a Work Package Lead The change is categorised as minor or major according to its impact on Project deliverables, learning outcomes, time, cost or impact on internal or external risks
- Minor changes will be presented at the weekly project meeting, discussed and challenged by the project team, approved or declined, and an action plan put in place
- Major changes will be defined along with supporting evidence, reason for change, proposed outcome for the change, and decided on by the project team. This will then be escalated to the PSB who will discuss the requested change and advise the Project on further action. If the change is deemed relevant, the change will be escalated to the PAG for advice and direction, at which point a scope change to the Project may be necessary.

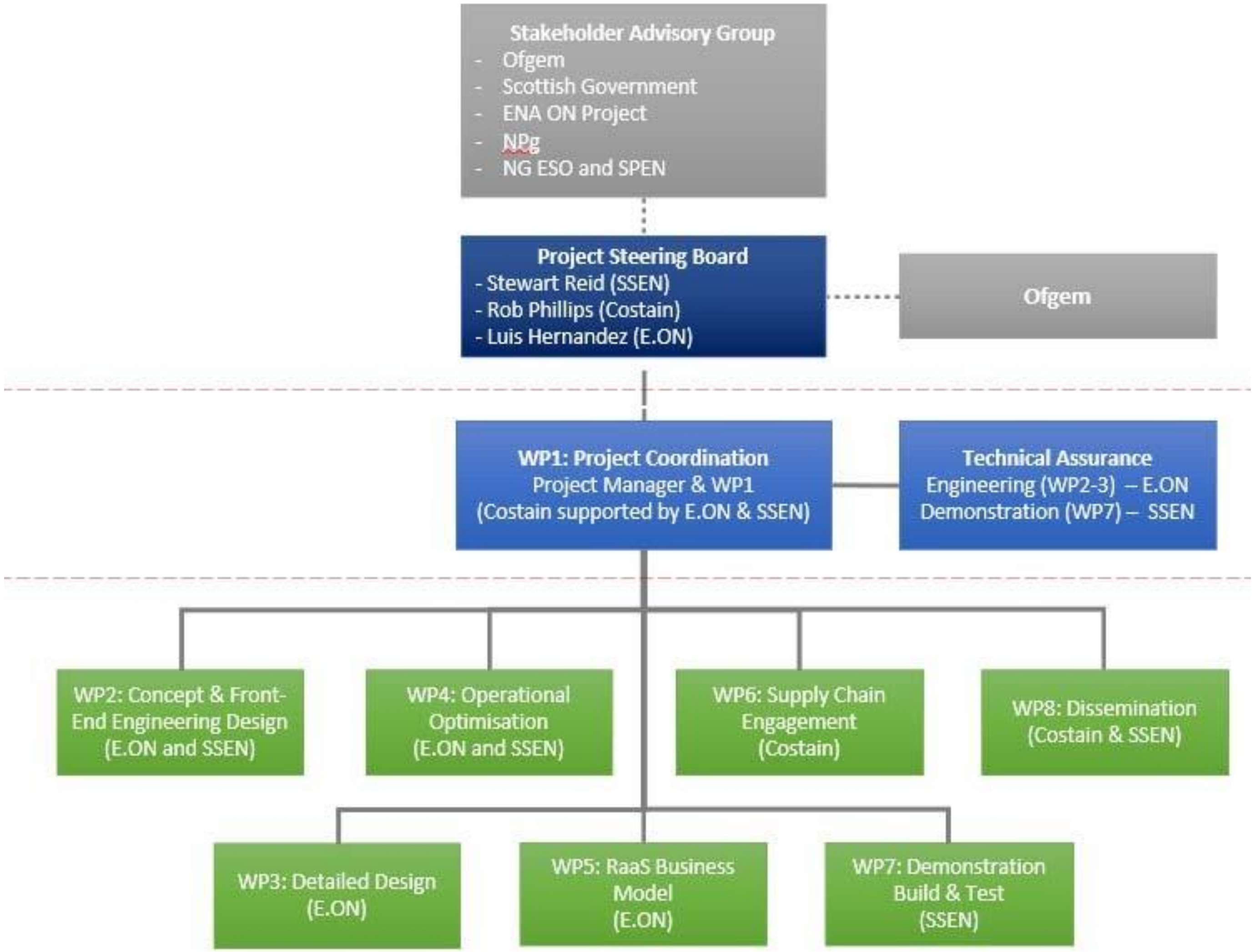


Figure 23: RaaS Project Organisation Chart

Appendix 11: Project Management Plan

Introduction

Ofgem have introduced a time-limited innovation stimulus package within the RIIO framework to provide an additional incentive to kick-start a cultural change where Network Licensees establish the ethos, internal structures and 3rd party contacts to facilitate innovation as part of business as usual. Part of this package is an annual Network Innovation Competition (NIC) competition to fund selected flagship innovative projects that could deliver low carbon and environmental benefits to customers. The Project will focus on a technical & commercial demonstration in the Scottish Hydro Electric Power Distribution licence area of Scotland. The SSEN demo will provide RaaS at 33kV/11kV transformers which connect to single communities via a long 33kV feeder. The proposed solution will use a single energy storage system.

The learning outcomes the Resilience as a Service (RaaS) Project intends to achieve are:

a) Understand how resilience can be supplied as a service
b) Demonstrate that the system components for the provision of resilience can be integrated into the network, with clarity on the division of scope of supply between the DNO and resilience supplier
c) Confirm that storage technology providing resilience is capable of achieving the expected revenue streams to minimise the cost of the resilience service
d) Understand the compromise between the provision of resilience and the ability to deliver resilience
e) Develop supply chain models for the provision of resilience, and understand how the service can be procured in the most cost-effective way
f) Disseminate Project results within the industry.

Management Activities

Risk and Opportunities Management

Our approach to risk management for this Project will be to use a structured, iterative process. This will allow individual and overall Project risk to be understood and managed, thereby minimising threats and maximising opportunities to optimise Project success.

Our risk process will comprise 5 stages:

i. Initiate. We will set the risk management process within the context and scope of the RaaS Project whilst accommodating overall Project objectives. The depth and level of the risk management process will be set.
ii. Identify. Each risk will be identified and confirmed as genuine, using a practical and cost-effective approach
iii. Assess. We will understand each risk to an extent that supports effective decision making, using a 5 x 5 risk threshold grid. Please refer to **Figure 27**.
iv. Plan responses. In this stage appropriate responses to each risk will be determined. Responses will be planned, and justification will assess response effectiveness, cost, significance of the risk to Project objectives and resources available.
v. Implement responses. Responsibilities for each risk response is well defined. Each risk will have an owner responsible for all aspects of its management,

control, reporting and implementation of mitigation actions. The risk may have a response actionee to implement the risk response actions. Both individuals

will attend the periodic risk meetings to discuss progress with the Project's inhouse risk expert.

Probability	Very high	0.9	0.045	0.09	0.18	0.36	0.72
	High	0.7	0.035	0.07	0.14	0.28	0.56
	Medium	0.5	0.025	0.05	0.1	0.2	0.4
	Low	0.3	0.015	0.03	0.06	0.12	0.24
	Very low	0.1	0.005	0.01	0.02	0.04	0.08
Risk threshold grid			Very low	Low	Medium	High	Very high
			0.05	0.1	0.2	0.4	0.8
			Impact				

High risk - +0.20 – Urgent attention, Medium risk – 0.08-0.2 – Regular review Low risk – below 0.08 – Monitor.

Figure 24: Risk Process – Example scoring grid

Since opportunities are effectively opposite to risks, they will be managed in a similar manner. Opportunities will be recorded in the risk and opportunities register and dealt with by:

a. Exploitation
b. Enhancement
c. Sharing
d. Acceptance or rejection.

Issue Management

An issue is a project event which is unplanned and requires immediate escalation to senior management. Our management approach will be similar to that for risks and opportunities i.e. we will capture and examine the issue then decide and implement the appropriate action. We will maintain an issues register which will, as a minimum, consist of the following elements:

i. Unique reference number
ii. Date issue was raised
iii. Person raising the issue
iv. Description
v. Cause and impact of the issue
vi. Severity rating (critical, major, significant or minor)
vii. Category of the issue e.g. commercial, technical or stakeholder
viii. Issue response action ix. Issue owner
x. How the issue was resolved, and any lessons learnt.

Contingency Planning

The project team has in place a robust contingency plan to deal with negative or disruptive events which may take place during the life of the RaaS project. These events may be political, technical, a natural disaster or linked to human resources. We have identified and earmarked the resources necessary to deal with such emergencies and have prioritised previously identified risks that might also trigger such events. Our contingency plan is supported by extant plans held by the project team's parent organisation and our plan will be periodically reviewed and updated.

Communication Management

Communications Plan

Our Communications Plan will align the actions necessary throughout the Project lifecycle with the agreed information flow to the client and other stakeholders. The Plan will identify our intentions with regard to each target audience and how our messages will be communicated. This will:

i. Persuade stakeholders of the Project benefits
ii. Educate stakeholders on the Project so they can make the necessary decisions
iii. Align stakeholders with the Project objectives
iv. Give stakeholders confidence and support.

All Project communications, whether by e-mail, face to face meetings or video conferencing, will have a definite purpose and conform to pre-defined parameters.

Schedule of Meetings

i. Quarterly Project Board Meetings to brief senior management
ii. Week project reviews chaired by Project Manager
iii. Monthly Risk Reviews chaired by risk lead attended by all risk owners and actionees.
iv. Monthly Change Meetings to consider change requests.

Change Management

The Project's change control process will ensure all changes made to the Project's baselined scope, time, cost and quality objectives are identified, evaluated, approved, rejected or deferred as appropriate. Our procedure is as follows:

a. Request – a Change Request Form is completed and the request is noted in the change register
b. Evaluation – the Change Panel will conduct an initial assessment and review any time, cost, quality or risk impact
c. Recommendation – the Change Panel will decide whether to accept, defer or reject the request and will communicate to all stakeholders
d. Update – all plans, schedules and baseline are updated as well as configuration records
e. Implement – the change is carried out and the change completion is noted in the change register.

Quality Management

The Quality Management System for this project will ensure the outputs of the Project and the processes by which they are delivered meet the required needs of the client and applicable stakeholders. Our quality process will ensure conformance and governance of output and process. Quality forms one dimension of the cost-time-quality triangle which are foundations for our success criteria and requirements. Therefore, they will be proactively managed within the context of the ISO 9000-2000 series where applicable.

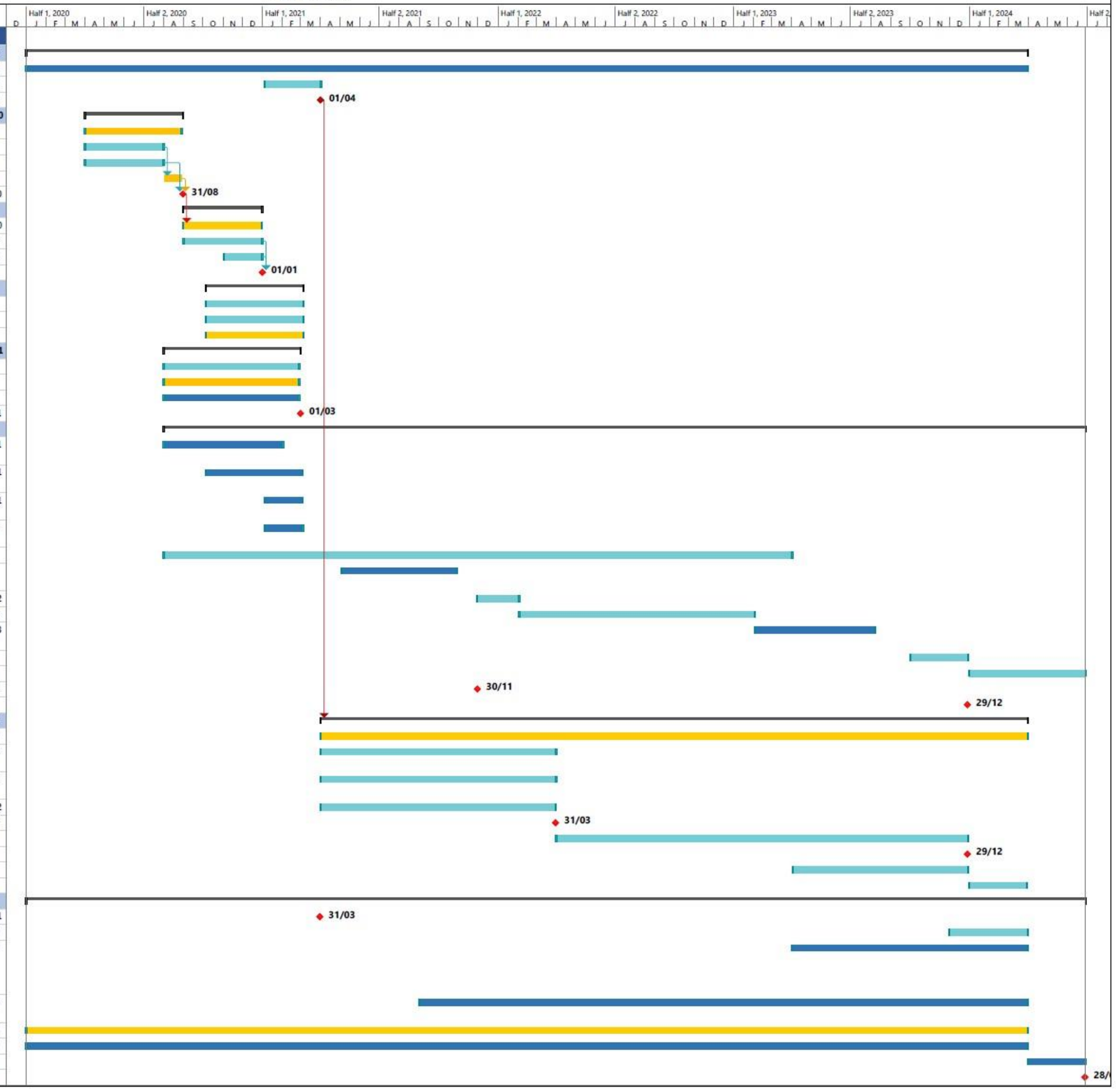
Health, Safety, Environment (HSE)

The Project team will undertake HSE management to determine and apply any appropriate standards to minimise the likelihood of accidents, injuries and environmental impact during the Project phases. We will take due account of the client's HSE policies, mandatory legislation and our own HSE policies to ensure HSE is prioritised in all Project work.

Appendix 12: Project Programme

NIC RaaS Project

ID	Task Name	Start	Finish
1	**NIC RaaS Project**		
2	**WP1- Project Coordination**	**Wed 01/01/20**	**Sun 31/03/24**
3	Project Co-ordination and technical management	Wed 01/01/20	Sun 31/03/24
4	Preparation of Deliverables prior to Stage Gate	Mon 04/01/21	Thu 01/04/21
5	**Stage Gate**	Thu 01/04/21	Thu 01/04/21
6	**WP2 Front-End Engineering Design**	**Wed 01/04/20**	**Mon 31/08/20**
7	DNO Integration and clarification of assets	Wed 01/04/20	Fri 28/08/20
8	Design FEED for the Resilience System	Wed 01/04/20	Fri 31/07/20
9	Site selection and Use Case(s) development	Wed 01/04/20	Fri 31/07/20
10	External Peer Review	Mon 03/08/20	Fri 28/08/20
11	**Project Deliverable 1**	Mon 31/08/20	Mon 31/08/20
12	**WP3 Detailed Design**	**Mon 31/08/20**	**Fri 01/01/21**
13	DNO Detailed Design for main project site	Mon 31/08/20	Wed 30/12/20
14	Design of Controls, BESS and electrical integration	Tue 01/09/20	Thu 31/12/20
15	Trial design	Mon 02/11/20	Thu 31/12/20
16	**Project Deliverable 2**	Fri 01/01/21	Fri 01/01/21
17	**WP4 Operational Optimisation**	**Mon 05/10/20**	**Fri 05/03/21**
18	Market analysis and techno-economic modelling	Mon 05/10/20	Fri 05/03/21
19	Demonstration platform development	Mon 05/10/20	Fri 05/03/21
20	DNO integration and modelling	Mon 05/10/20	Fri 05/03/21
21	**WP5 Business Model**	**Sat 01/08/20**	**Mon 01/03/21**
22	Construct investment business case and revenue stacking for RaaS supplie	Sat 01/08/20	Fri 26/02/21
23	Legal review and development of commercial terms	Sat 01/08/20	Fri 26/02/21
24	Draft Heads of Terms for RaaS method	Sat 01/08/20	Fri 26/02/21
25	**Project Deliverable 3**	Mon 01/03/21	Mon 01/03/21
26	**WP6 Future Supply Chain & Engagement**	**Sat 01/08/20**	**Fri 28/06/24**
27	Deep dive investigation into the full applications of the RaaS across GB	Sat 01/08/20	Mon 01/02/21
28	Create system model and enterprise design of the RaaS system	Mon 05/10/20	Wed 03/03/21
29	Risk Analysis, comparison with global experience	Mon 04/01/21	Wed 03/03/21
30	Market Study of supply chain skillsets to identify optimum roles in RaaS market	Mon 04/01/21	Thu 04/03/21
31	Continued stakeholder engagement on learning outcomes	Sat 01/08/20	Sat 01/04/23
32	Create P13 enterprise design from system model and draw up commercial strategy	Mon 03/05/21	Fri 29/10/21
33	Risk rating and suggested procurement method for each	Tue 30/11/21	Wed 02/02/22
34	Define procurement activity incorporating earlier outcomes	Thu 03/02/22	Thu 02/02/23
35	Consultation on commercial strategy, procurement methodology, RaaS values and ENA	Fri 03/02/23	Mon 07/08/23
36	Set Procurement strategy	Mon 02/10/23	Fri 29/12/23
37	Technical Design to support second demonstration site	Mon 01/01/24	Fri 28/06/24
38	**Project Deliverable 5**	Tue 30/11/21	Tue 30/11/21
39	**Project Deliverable 8**	Fri 29/12/23	Fri 29/12/23
40	**WP7: Demo Build & Test**	**Thu 01/04/21**	**Sun 31/03/24**
41	Customer Liasion	Thu 01/04/21	Sun 31/03/24
42	Design Freeze and Procurement of Assets, Products and Services	Thu 01/04/21	Thu 31/03/22
43	Permitting and Construction of RaaS and network Assets and control	Thu 01/04/21	Thu 31/03/22
44	Integration, Testing and Commissioning	Thu 01/04/21	Wed 30/03/22
45	**Project Deliverable 6**	Thu 31/03/22	Thu 31/03/22
46	Operation, Monitoring and Optimization	Fri 01/04/22	Fri 29/12/23
47	**Project Deliverable 7**	Fri 29/12/23	Fri 29/12/23
48	Validation of Business Case & Assumptions	Mon 03/04/23	Fri 29/12/23
49	Decommissioning	Mon 01/01/24	Fri 29/03/24
50	**WP8: Dissemination**	**Wed 01/01/20**	**Fri 28/06/24**
51	**Project Deliverable 4**	Wed 31/03/21	Wed 31/03/21
52	Produce technical documentation	Fri 01/12/23	Sun 31/03/24
53	Soft market testing, Meet the buyer roundtable event, Consultation exercise with potential RaaS providers, designers, engineering service providers, Linking the risk profile to reward mechanisms	Sat 01/04/23	Sun 31/03/24
54	Present at conferences and supplier events to advertise the market's potential	Wed 01/09/21	Sun 31/03/24
55	Dissemination at events, webinars, stakeholder groups etc.	Wed 01/01/20	Sun 31/03/24
56	Continuous market and stakeholder engagement	Wed 01/01/20	Sun 31/03/24
57	Preparation of Final Reports	Mon 01/04/24	Fri 28/06/24
58	**Project Deliverable 9**	Fri 28/06/24	Fri 28/06/24



Appendix 13: Risk Register

Since the RaaS Project was initiated our team has worked hard to identify, analyse, plan and manage risks and opportunities to mitigate risks and seize opportunities. It has been our coherent and consistent communication within the project team that has been the primary factor in our success with early risk management. This pragmatic approach has allowed us to reduce the potential impact of these risks and is reflected in our risk register by the low impact scores.

Risk I.D.	Risk Cat.	Date Raised	Risk Description	Impact	Probability of risk occurring	Project impact if risk occurs	Expected Value for each Risk	Description of proposed risk response	Mitigated probability	Mitigated impact	Mitigated value	Risk owner	Status
RRaaS001	Technical	01 July 2019	The project fails to deliver the expected financial and technical benefits expected.	Lower than expected value delivered	4	5	20	1. Identify and enact specific technical risks and mitigations. 2. Analyse benefits to ensure they are measurable, realistic and achievable. 3. Scope alternative technical solutions.	2	3	6	Project manager	Open

RRaaS002	Technical	01 July 2019	Significant involvement for single supplier of RaaS creates an uncompetitive market post-project.	After project is completed, the supply chain is not able to respond to the call for tender.	4	5	20	1. Parallel to the project, the supply chain lead will engage, inform and map suppliers; reducing the competitive advantage each supplier has. 2. Fair and transparent procurement practices instilled from day one and Costain selected as an independent custodian of the supply chain engagement exercise on behalf of GB DNO's.	1	3	3	Supply chain lead	Open
RRaaS003	Technical	01 July 2019	The project requirements and deliverables are ambiguous.	Requirements creep and loss of confidence will occur.	3	4	12	1. The project partners, stakeholders and Ofgem workshop and agree requirements and deliverables. 2. The ISO 15288 standard is used to ensure each agreed requirement has a viewpoint, action, subject, effectiveness measures and conditions.	1	2	2	Project manager	Open

RRaaS004	Technical	03 June 2019	Circuits that require resilience are constrained such that the storage system providing resilience can't operate in different markets.	Cost of resilience can't be reduced to economically viable levels and traditional reinforcement is more economically viable.	3	7	21	1. Initial scoping and feasibility studies have been completed ahead of FSP submission resulting in multiple identified potential areas for demonstration. 2. Commissioned TNEI for an independent verification of the business case of the Resilience as a Service solution showing +£100m of saving for GB until 2050.	1	3	3	Project manager	Open
RRaaS005	Technical	01 July 2019	The revenue generated from other markets by the RaaS provider fail to reduce the cost of resilience to an economical level.	The learning outcome that provision of market revenues and resilience are mutually exclusive.	3	5	15	1. The learning outcome results in a deviation or stop in the project and the advisory board and Ofgem are consulted for further project direction. 2. RaaS technical solution has been designed to incorporate multiple potential opportunities for revenue streams to be accessed by RaaS provider.	2	4	8	Project manager	Open

RRaaS005	Social	01 July 2019	Stakeholders develop inaccurate expectations.	Stakeholders will lose confidence in and support to project.	3	5	15	1. Project partners and other stakeholders have agreed to the project requirements. 2. These derived requirements are widely disseminated to all stakeholders as part of the stakeholder engagement. 3. The project team ensure expectation management is conducted with Ofgem and all stakeholders.	3	3	9	Project manager	Open
RRaaS006	Technical	01 July 2019	The RaaS solution, its design and implementation are more complex than first thought.	Application of RaaS is not feasible and project stops.	5	5	25	1. Planned stage gate the RaaS solution not being feasible or best value for money for customers. If results a negative outcome in either case the project will stop. 2. Preliminary feasibility and preliminary designs done pre-project start both indicating positive outcomes. 3. Ensure best value for money and whole system analysis for RaaS solution.	3	4	12	Project manager	Open

RRaaS007	Technical	01 July 2019	Suitable sites for the trials prove inadequate or are not available.	Costs increase, confidence lost and the project is delayed.	3	5	15	1. Early engagement with local stakeholders to facilitate use of preferred and alternative sites. 2. Use regional and local knowledge of stakeholders to identify all possible sites.	3	4	12	Project manager	Open
RRaaS008	Technical	01 July 2019	Integration of equipment and systems not achievable or takes longer than planned.	Costs increase and alternative funds required for the completion of the project.	4	5	20	1. Ensure early scoping of alternative suppliers. 2. Lessons learnt brought from E.On's Simris project as well as desk top system integration exercise undertaken pre-project start. 3. Work closely with prime suppliers to understand full system capabilities and limitations.	3	4	12	Technical Advisor	Open

RRaaS009	Political	01 July 2019	UK legislation changes forces project mandate, deliverables and requirements to change.	Project will be delayed or require re-scoping.	1	3	3	1. Closely monitor any legislative proposed changes. 2. Consortium have aligned scope and intent of the project with key energy network needs for more effective resilience and flexibility. 3. 3rd party independent study undertaken proving a return on investment for the project concept.	1	1	1	Project manager	Open
RRaaS010	Social	03 June 2019	Risk of outage during project demonstration is deemed unacceptably high.	If sensitive loads that can be not tolerated the demonstrations can't be carried out	1	5	5	1. Sensitivity analysis to be performed as part of the detailed design phase of the trial. 2. Stage gate allows for stopping of the project if the risk of disruption to local customers is deemed too high. 3. Close stakeholder engagement focus throughout the project.	1	2	2	DNO licensee	Open

RRaaS011	Economic	01 July 2019	Non-BAU technology proves to be more expensive than previously expected.	Project overspend requiring additional partner contribution or request to Ofgem for additional funding.	4	5	20	1. Ensure costs are realistic with an agreed appropriate contingency based on experience. 2. Inclusion of Technical experts for each workpackage to provide better confidence estimations of components and services. 3. Prove best value for money for high cost items through effective tendering process. 4. Review costs, cost forecasts and scope at the end of each gate and phase.	2	3	6	Project manager	Open
RRaaS012	Economic	01 July 2019	Lack of business support from partner organisations.	Intra organisational tensions increase causing delays or withdrawal from the project.	3	4	12	1. Project Steering Board established to show company commitment and to act as a route for dispute escalation. 2. Project team to ensure intra organisational briefings and updates are routine, frequent and informative. 3. Statement of commitment written by all party members.	1	1	1	Project manager	Open

Appendix 14: Funding Commentary

Funding Contributions

As licensee, Scottish and Southern Electricity Networks shall provide the compulsory contribution of 10% overall project costs for Resilience as a Service (RaaS). In addition, partners E.ON and Costain have both provided at least a 10% in-kind contribution through discounting the standard rate for each of their identified resources. The discount has been applied to their rates prior to inclusion within the Full Submission Spreadsheet.

All costs outlined below are the 19/20 prices (i.e. do not include inflation). Within the Full Submission Spreadsheet all estimated costs have been inflated by the annual inflation rates provided by Ofgem.

Personnel Cost (19/20 prices)

A summary of estimated person days is included in Table 1 for each Partner and for external resource. The average day rate for the Project for each partner is as follows:

- SSEN £XXX [redacted]
- E.ON £XXX [redacted]
- Costain £[redacted]

All other external resource costs are based on an average rate of £[redacted] per day (based on the assumption that this is expert professional resource).

SSEN has benchmarked these rates against existing framework arrangements with similar suppliers, acquired via the competitive procurement process.

	SSEN	Costain	E.ON	External	FTE (annualised)	Total personnel cost £
Phase 1	[redacted]	[redacted]	[redacted]	[redacted]	9.3	[redacted]
Phase 2	[redacted]	[redacted]	[redacted]	[redacted]	6.8	[redacted]

Figure 25: RaaS Personnel Costs

Work package breakdown of costs (19/20 prices)

A summary of key tasks and equipment/external resource is included in the bullet points under each work package heading. We also note that travel and expenses costs include provision for hire of event space in London or other major city for the main stakeholder engagement events.

WP1 Project Coordination - £1,540,534

WP1 contains all core project management activities carried out by each partner, with Costain leading the overall coordination. This includes £[redacted] for stage gate process and documentation.

- [redacted] Costain person days
- [redacted] SSEN person days
- [redacted] E.ON person days

WP2 Front-End Engineering Design - £285,138

Initial design phase for the proposed method forming the foundations on which the detailed design for the demonstrator should build.

- [redacted] SSEN person days
- [redacted] E.ON person days
- £[redacted] external peer review

WP3 Detailed Design - £813,285

Detailed design concentrates on the technical design of the method and setting of the parameters in which the trial will operate.

- [redacted] SSEN person days
- [redacted] E.ON person days
- £[redacted] ANM enablement and control equipment for the project.
- £[redacted] external resource for IT and OT control enablement.

WP4 Operational Optimisation - £298,565

The conversion of market interactions analysis into a practical control system to be demonstrated in the operational phase of the project.

- [redacted] E.ON person days
- [redacted] SSEN person days
- £[redacted] academic support with WP deliverables.

WP5 Business Model - £525,056

Detailed Design and Operational Optimisation outputs are brought together and expanded to form the Business Model for potential RaaS suppliers.

- [redacted] Costain person days
- [redacted] SSEN person days
- [redacted] E.ON person days
- £[redacted] external specialist legal resource for Heads of Terms development

WP6 Supply Chain Engagement - £641,671

Accelerating the pace of RaaS market development by ensuring all DNOs and other potential MPs have the skills, tools and confidence to procure or provide RaaS solutions. This also includes site selection and design work for second demonstration site.

- [redacted] Costain person days
- [redacted] SSEN person days
- [redacted] E.ON person days

WP7 Demonstration Build and Test - £5,402,249

Construction of the demonstrator and its implementation based on the Detailed Design and Trial Programme.

- [redacted] E.ON person days.
- [redacted] SSEN person days
- [redacted] person days external support for specialist construction and demonstration
- £[redacted] includes equipment to prepare the DNO network for the trial, including additional protection measures. This includes: ANM controller and comms costs for BESS and other DER, 11kV GIS switchgear, protection panel and CTs, relays, 11kV cable, standby generator and network monitoring assets.
- £[redacted] includes equipment for the RaaS supplier demonstration including: Battery Energy Storage System (BESS) rental, 11kV GIS switchgear (customer), 3MVA 11/0.5kV Transformer (customer), earthing impedance and switchgear, Energy Management System (EMS), EMS control room integration, BESS supplier system stability modelling and solution design.
- £[redacted] decommissioning costs

WP8 Dissemination - £729,066

WP8 contains all dissemination and documentation for the project as a whole and all work package specific activities.

- [redacted] Costain person days
- [redacted] SSEN person days
- [redacted] E.ON person days
- £[redacted] external design support

Appendix 15: Full Submission Spreadsheet

The Full Submission Spreadsheet is attached to the submission as a separate .xlsx file and named ***RaaS Proposal - Full Submission Spreadsheet V1***

NIC Funding Request

Section	Item	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	Total		
Total Project Cost	*From Project Cost Summary sheet*										
	Labour	32,438	318,240	486,779	358,914	244,915	48,030	-	1,489,316		
	Equipment	-	211,560	2,440,527	656,880	-	-	-	3,308,967		
	Contractors	30,000	2,020,673	1,988,553	532,590	691,000	-	-	5,262,815		
	IT	-	-	-	-	-	-	-	-		
	IPR Costs	-	-	-	-	-	-	-	-		
	Travel & Expenses	10,000	95,594	160,506	143,287	104,283	-	-	513,671		
Payments to users & Contingency		-	-	-	-	-	-	-	-		
	Decommissioning	-	-	-	-	356,338	-	-	356,338		
	Other	-	-	-	-	-	-	-	-		
	Total	72,438	2,646,067	5,076,365	1,691,671	1,396,536	48,030	-	10,931,107		
External funding	*Any funding that will be received from Project Partners and/or External Funders - from Project Cost Summary sheet*										
	Labour	-	-	-	-	-			-		
	Equipment	-	-	-	-	-			-		
	Contractors	-	-	-	-	-			-		
	IT	-	-	-	-	-			-		
	IPR Costs	-	-	-	-	-			-		
	Travel & Expenses	-	-	-	-	-			-		
Payments to users & Contingency		-	-	-	-	-			-		
	Decommissioning	-	-	-	-	-			-		
	Other	-	-	-	-	-			-		
	Total	-	-	-	-	-	-	-	-		
Licensee extra contribution	*Any funding from the Licensee which is in excess of the Licensee Compulsory Contribution - from Project Cost Summary sheet*										
	Labour	-	-	-	-	-			-		
	Equipment	-	-	-	-	-			-		
	Contractors	-	-	-	-	-			-		
	IT	-	-	-	-	-			-		
	IPR Costs	-	-	-	-	-			-		
	Travel & Expenses	-	-	-	-	-			-		
Payments to users & Contingency		-	-	-	-	-			-		
	Decommissioning	-	-	-	-	-			-		
	Other	-	-	-	-	-			-		
	Total	-	-	-	-	-	-	-	-		
Initial Net Funding Required											
	Labour	32,438	318,240	486,779	358,914	244,915	48,030	-	1,489,316		
	Equipment	-	211,560	2,440,527	656,880	-	-	-	3,308,967		
	Contractors	30,000	2,020,673	1,988,553	532,590	691,000	-	-	5,262,815		
	IT	-	-	-	-	-	-	-	-		
	IPR Costs	-	-	-	-	-	-	-	-		
	Travel & Expenses	10,000	95,594	160,506	143,287	104,283	-	-	513,671		
Payments to users & Contingency		-	-	-	-	-	-	-	-		
	Decommissioning	-	-	-	-	356,338	-	-	356,338	Check Total = to Initial Net Fundi	
	Other	-	-	-	-	-	-	-	-	in Project Cost Summary	
	Total	72,438	2,646,067	5,076,365	1,691,671	1,396,536	48,030	-	10,931,107	OK	
Direct Benefit: *from Direct Benefits sheet*											
	Total	-	-	-	-	-	-	-	-		
Licensee Compulsory Contribution	*from Project Cost Summary sheet*										
	Labour	3,244	31,824	48,678	35,891	24,491	4,803	-	148,932		
	Equipment	-	21,156	244,053	65,688	-	-	-	330,897		
	Contractors	3,000	202,067	198,855	53,259	69,100	-	-	526,282		
	IT	-	-	-	-	-	-	-	-		
	IPR Costs	-	-	-	-	-	-	-	-		
	Travel & Expenses	1,000	9,559	16,051	14,329	10,428	-	-	51,367		
Payments to users & Contingency		-	-	-	-	-	-	-	-		
	Decommissioning	-	-	-	-	35,634	-	-	35,634	of Total Initial Net Funding Requi	
	Other	-	-	-	-	-	-	-	-	OK	
	Total	7,244	264,607	507,637	169,167	139,654	4,803	-	1,093,110.74	Check that **Total** is = or > than Total Direct Benefits	
										OK	
Outstanding Funding required											
	Labour	29,194	286,416	438,101	323,022	220,423	43,227	-	1,340,384		
	Equipment	-	190,404	2,196,475	591,192	-	-	-	2,978,071		
	Contractors	27,000	1,818,606	1,789,697	479,331	621,900	-	-	4,736,534		
	IT	-	-	-	-	-	-	-	-		
	IPR Costs	-	-	-	-	-	-	-	-		
	Travel & Expenses	9,000	86,035	144,456	128,959	93,855	-	-	462,304		
Payments to users & Contingency		-	-	-	-	-	-	-	-		
	Decommissioning	-	-	-	-	320,704	-	-	320,704	Check that Total is =to	
	Other	-	-	-	-	-	-	-	-	Total Outstanding Funding requi	
	Total	65,194	2,381,461	4,568,729	1,522,504	1,256,882	43,227	-	9,837,997	OK	
balance	9,696,262.01	0.00	7,249,608	2,733,835	1,273,727	41,892	6,888	7,192	(1,206,767)	9,696,262	
interest		0.00	52,956	62,397	25,047	8,223	305	88	(7,280)	141,735	
										9,837,997	-

Bank of England interest rate	0.75%	NIC FUNDING REQUEST £	9,696,262
interest rate used in calculation	1.3%		

Appendix 16: Glossary of Terms

Term	Definition	Term	Definition

ADMD	After Diversity Maximum Demand	LCT	Low carbon technologies
ANM	Active Network Management	LV	Low voltage
BAU	Business as usual	MBSE	Model-based systems engineering
BESS	Battery energy storage system	MP	Market participant
CBA	Cost benefit analysis	MV	Medium voltage
CI	Customer interruptions	MW	Megawatts
CML	Customer minutes lost	MWh	Megawatts per hour
DER	Distributed energy resources	NIA	Network Innovation Allowance
DERMS	Distributed Energy Resource Management Systems	NPg	Northern Powergrid
DNO	Distributed network operator	OHL	Overhead lines
DSO	Distribution system operator	ON	Open Networks
EFFS	Electricity Flexibility and Forecasting System	P13	Project 13 (IEE) delivery model for infrastructure
EHV	Extra high voltage	PAG	Project Advisory Group
EMS	Energy Management System	PM	Project Manager
ENA	Energy Networks Association	PMP	Project Management Plan
ESO	Electricity System Operator	POC	Point of contact
ESO	National Grid Electricity System Operator	PSB	Project Steering Board
EV	Electric Vehicle	QSS	Quality of Supply Standard
GB	Great Britain	RaaS	Resilience as a service
GW	Gigawatts	S/S	Sub-station
HSE	Health, safety & environment	SHEPD	Scottish Hydro Electric Power Distrib’n.
HV	High voltage	SQSS	Security & Quality of Supply Standard
IPR	Intellectual property rights	SSEN	Scottish & Southern Electricity Networks
ISP	Initial screening process	TRL	Technology readiness level

KPI	Key performance indicator	WP	Work package
LCNI	Low carbon networks & innovation conference		