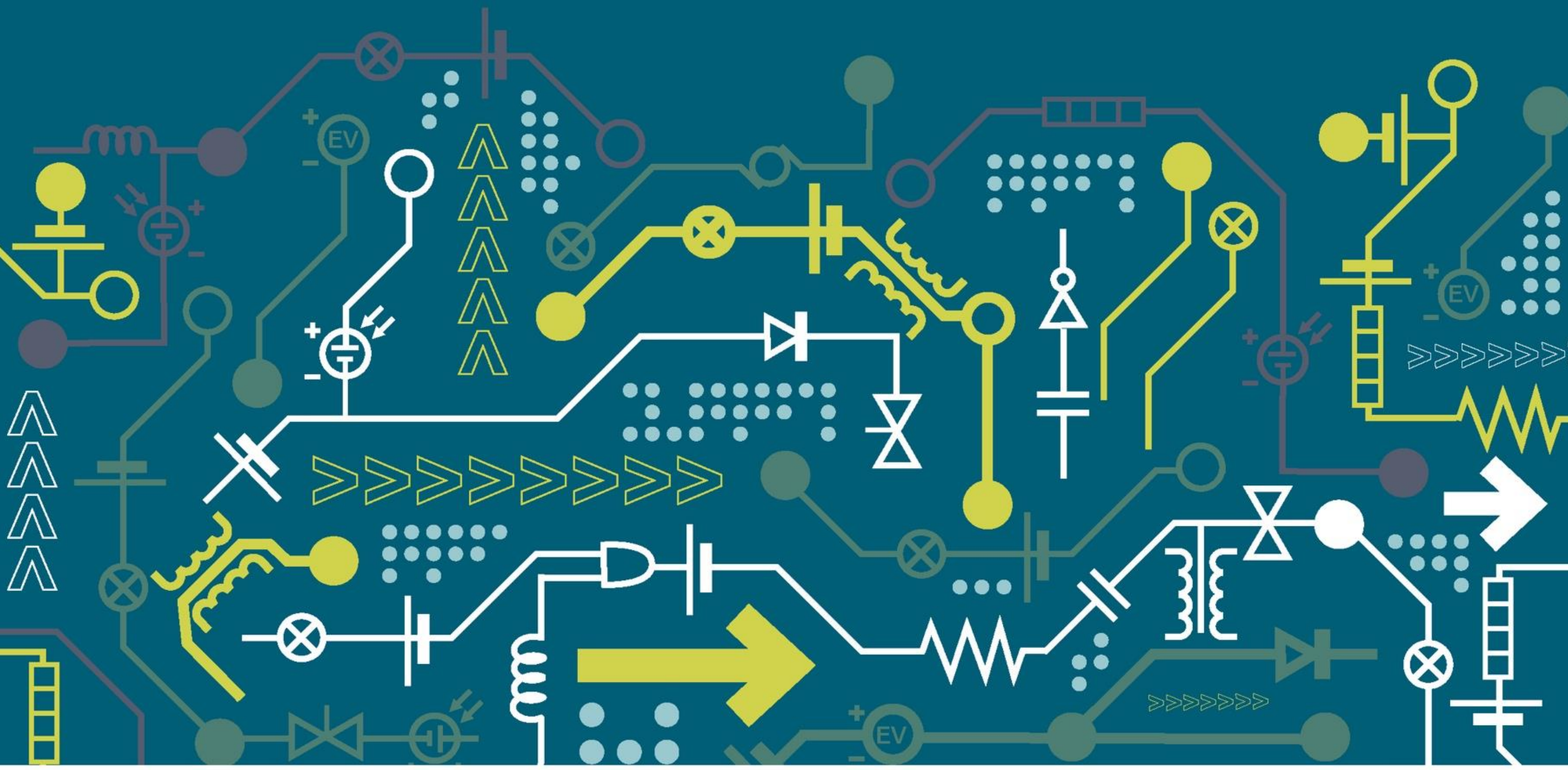
Network Islanding Investigation

Closedown Report



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1 Executive Summary

Supporting the connection of new flexible Distributed Energy Resources (DER) to the distribution network is an extremely important aspect to support the transition to a low carbon network and lower costs for network customers. As such, Distribution Network Operators (DNOs) are investigating new methods to accommodate the increasing volumes of low carbon technologies (LCTs) and Distributed Generation (DG). These new methods typically need to provide much higher levels of network flexibility, whilst maintaining the existing standards for safety and network security.

A network island is defined as a section of network that is able to detach from the main interconnected grid and remain energised by local DG. DNOs currently employ automated protection systems to remove network islands from supply when they are detected, as there is no mechanism to balance the DG output with the island demand, which can lead to large deviations in system frequency and voltage within the island. Network islands can also represent a significant safety risk if they are not detected, as operational engineers may believe the network is “dead” when it is in fact still energised by DG.

This study, however, has sought to investigate whether intentionally islanding parts of the distribution network in a controlled and safe manner could offer benefits to network customers, especially noting trends indicating that generation is becoming more de-centralised and customers wish to consume power from locally installed low carbon generation sources. In addition, it was foreseen that islanding parts of the network could represent a new mechanism for DNOs to increase network flexibility and assist in the transition to Distribution System Operator (DSO).

The Network Islanding Investigation project involved research and studies into the technical, legal, regulatory and commercial aspects of islanded networks to understand if this approach could deliver significant benefits for customers. The project identified several trial areas where islands could be formed on parts of the 33kV networks with demands in the order of 20MW. The work established that network islands could be implemented from a technical perspective, with various manufacturers able to provide technologies to facilitate the transition from grid-connected to island operation. The studies found that on average the typical costs to convert a network to operate safely and securely as an island would be £512k. The costs include for the provision of new switchgear, relays and control equipment to ensure that network can operate within statutory limits with no impact on customer supplies.

A detailed review of the legal and regulatory frameworks, ownership structures and operational responsibilities, including developments relating to DSO and charging arrangements, was also completed. The review concluded that islanding the network could be achievable without changes to the existing regulatory frameworks. It was also noted that there are a number of ongoing external activities relating to updates and changes to markets for flexibility, provision of data and forward/locational price signals that could help complement islanding of networks.

The final element of the study investigated the commercial aspects of network islanding. A bottom-up and top-down Cost Benefit Analysis (CBA) was completed for a number of trial sites to establish if financial benefits could be achieved over a 20 year period. The study found that this resulted in a negative cumulative Net Present Value (NPV) in all cases. However, the analysis found that it may be possible to obtain additional revenues to make network islanding attractive especially with the ongoing work into reviews of charging methodologies and frameworks. As such, it is recommended that the CBA for network islanding should be reviewed again in three years to determine whether additional revenues can be achieved.

In summary, the Network Islanding Investigation project has generated extremely valuable learning in relation to the technical, legal, regulatory and commercial aspects of operating distribution networks in a more flexible arrangement. Unfortunately, the work found that it is not possible to achieve financial benefits at the present time, however, further research should be conducted again in the next three years to understand the impact of changes in charging methodologies and other possible revenue streams.

2 Project Background

The distribution network requires increasing levels of network flexibility and other dynamic solutions to facilitate the transition to a low carbon economy and provide low cost connections for increasing volumes of Distributed Generation (DG) and Low Carbon Technologies (LCTs). The use of flexibility and other new solutions must ensure that existing standards for safety, quality or security of supply are maintained.

The existing distribution network across Great Britain (GB) has not been planned or designed to operate as an island. Island operation would occur when part of the licensed network remains in operation despite being disconnected from the main distribution network (i.e. part of the network is isolated during a fault). Presently, the network and DG are equipped with local protection and control systems that detect when islanded operation occurs. These protection schemes ensure that disconnected parts of the network remain de-energised to avoid uncontrolled power flows, voltages and frequencies, thus enabling a safe and secure network.

The Network Islanding Investigation project sought to investigate whether Distribution Network Operators (DNOs) could intentionally island certain sections of the network in a safe and secure manner and whether this would represent a new mechanism to increase network flexibility. The hypothesis is that network islanding could yield significant benefits for customers and assist DNOs with the transition to Distribution System Operator (DSO).

Currently, there are only a limited number of approaches to active management of the network to provide flexibility services while maintaining safety requirements. Intentionally islanding of distribution network is a significant departure to the present operational philosophy of the network where it is seen as an undesirable network operating scenario. The main aims of the project were to research and study the technical, commercial, regulatory and legal aspects of adopting network islanding as a new mechanism for DNOs.

3 Scope and Objectives

The main objectives of the Network Islanding Investigation project were to understand the technical, commercial, regulatory and legal aspects that would need to be considered before islanding parts of the network. In addition, the project would also investigate the potential benefits of operating parts of the distribution network in islanded mode under different conditions.

The investigation of islanded operation is necessary to demonstrate that, while commonly considered to be undesirable, it may provide a valuable additional solution for operators to actively manage the network and add to the 'toolkit' to provide flexibility when acting in the role of DSO.

The scope ranged from conducting preliminary research and analysis through to power system analysis on areas of our existing network.

Table 3.1 provides a summary of the main objectives and their status following completion of the project.

Table 3.1 Summary of project objectives

Objective	Status
Conduct desktop research to identify different suitable technical approaches to network islanding along with a preliminary assessment of any current legal, regulatory or commercial barriers that exist and the costs and benefits of each approach	✓
Carry out a feasibility study that will identify suitable areas of WPD network that would benefit from the network islanding approaches	✓
Network modelling and analysis to demonstrate the operation of the islanding approaches and to quantify benefits	✓
Detailed investigation of the legal and regulatory issues that may impact the implementation of an islanded network and proposed solutions and revised methodologies to enable implementation	✓
A final report that will present the findings of the investigation, including learning related to technology integration on the network and recommendations for further project development	✓

It can be seen from Table 3.1 that all the objectives for the Network Islanding Investigation project were completed successfully.

4 Success Criteria

The project successfully met the criteria specified in the original "NIA Project Registration and PEA document" dated January 2019. The success criteria for the project are summarised in Table 4.1.

Table 4.1 Project success criteria

Success Criteria	Status
Review network island case studies from across the world and literature relevant to network islanding on distribution networks. **Complete – case studies and literature review captured within the "High Level Review" report dated April 2019**	✓
Understand if it is technically possible to implement network islanding on parts of WPD's distribution network and the equipment required to do achieve this. **Complete – network islanding is technically feasible with further details on identification of islands, costs and other considerations captured in the "Feasibility Study" report dated August 2019 and the "Investigation Findings Report" dated January 2020**	✓
Review of the legal and regulatory requirements that could affect the implementation of the network islanding on distribution networks in GB. **Complete – legal and regulatory requirements explored in the "High Level Research and Analysis" report dated April 2019 and the "Investigation Findings Report" dated January 2020**	✓
Analysis of the commercial considerations and implications of adopting network islands on the distribution networks in GB. **Complete – commercial analysis for network islanding is presented using a bottom-up approach in "Feasibility Study" report dated August 2019 and a top-down approach in the "Investigation Findings Report" dated January 2020**	✓
Dissemination of information, processes and learning that have been generated throughout the course of the project **Complete – all the research, analysis and studies were summarised and presented in the final "Investigation Findings Report" dated January 2020**	✓

The research, analysis and studies carried out as part of the project have generated substantial learning on the technical, commercial and regulatory feasibility of network islanding, including how environmental, financial and capacity benefits can be measured.

5 Details of the work carried out

5.1 Introduction

The delivery of the Network Islanding Investigation project was split into seven separate tasks as summarised in Table 5.1 and detailed within the following sections of the report.

Table 5.1 Project tasks

Task Number	Title
1	Data Gathering
2	High-Level Review
3	High-Level Research and Analysis
4	Feasibility Study
5	Further Investigation
6	Network Modelling
7	Investigation Findings Report

5.2 Data Gathering

The first task for the project involved gathering a range of data from various sources to inform the delivery of subsequent tasks. The project team gathered data for the following key areas:

- **Manufacturer literature** – providing details of existing systems that could be used to control and monitor network islands;
- **Technical papers** – to investigate the implementation of network islands on other distribution networks across the world;
- **Industry regulation and legislation** – to understand the requirements for ensuring a safe, reliable and resilient network;
- **Electricity standards and specifications** – to confirm the latest planning, design and operational requirements for the distribution network;
- **Customer data** – to understand the different types of customer that may be within an island and their typical consumption charges and patterns;
- **Power flow data** – to understand the typical load profiles of the network islands and the export of generation within an network island;
- **Network data** – to replicate the selected trial areas in the DIgSILENT software for network studies; and
- **Generator data** – to model individual generating sets and their Automatic Voltage Regulators (AVRs)/Controllers to allow an assessment of system stability.

This data was collated by the project team and referenced accordingly in the project reports and deliverables.

5.3 High-Level Review

The High-Level Review Report captured the current approaches of network islanding and assessed the viability and practicality of these as a solution for DNOs and/or customers to release benefits.

The report explored the concept of islanding networks and the high-level technical requirements for establishing a network island on an existing distribution network. The issues, drivers and identification of islanding approaches were also investigated and summarised with the report. Finally, case studies were presented for network islands that had been established Denmark, Canada and the USA highlighting the motivation for islanding, the benefits/barriers and the main features of the network.

Figure 5.1 shows extracts from the High-Level Review report.

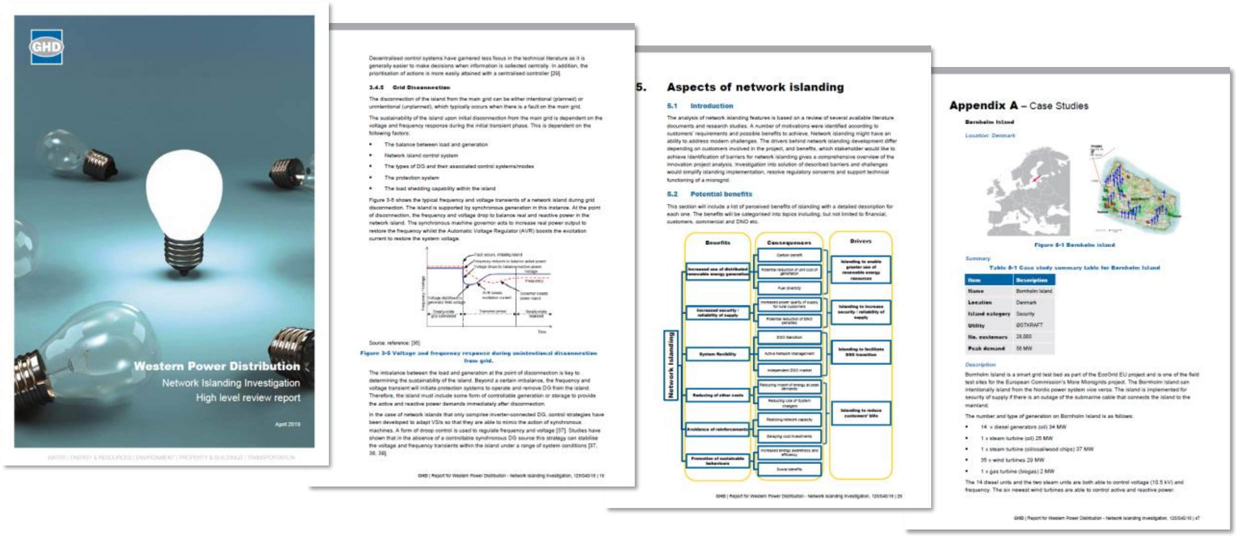

Figure 5.1 Extracts from High-Level Review report

5.4 High-Level Research and Analysis

Three main areas were investigated within the High-Level Research and Analysis report: legal considerations, regulatory considerations and commercial considerations.

The legal and regulatory framework underpins all of the activities in the sector and the analysis confirmed that the modification of legislation and regulation naturally lags behind technological developments, such as network islanding. However, there were no significant barriers in these areas to network islanding with the exception of definitions relating to the operation of generation or energy storage by a DNO. However, it was identified that this was already being considered by Ofgem under various consultations.

Figure 5.2 shows extracts from the High-Level Research and Analysis report.

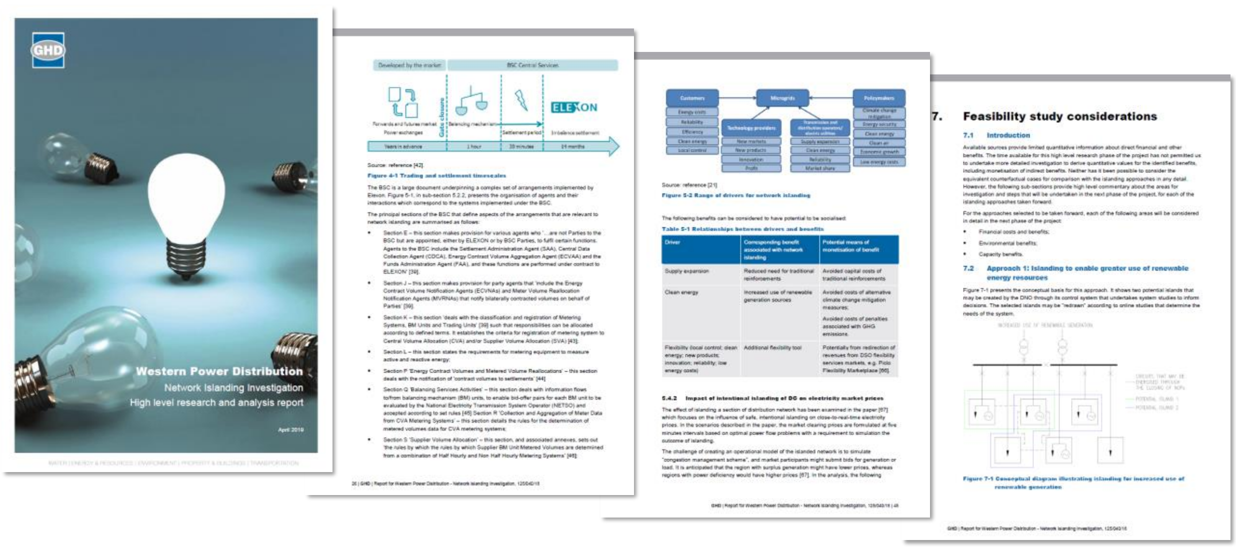

Figure 5.2 Extracts from High-Level Research and Analysis report

5.5 Feasibility Study

This study investigated the feasibility of network islanding by implementing a Cost Benefit Analysis (CBA) of the approach when applied to selected trial networks. The report presents the methodology that was employed; the technical criteria and assumptions that were used; and the subsequent results of the CBA along with associated commentary. In addition, the Feasibility Study continued the work that had been completed in the high-level review and high-level research and analysis reports.

The report delivered the following main outputs:

- The methodology for identification of possible trial networks for the study;
- The identification of technical criteria to allow the selection of the trial networks for the study;
- The assumptions used to underpin the technical requirements for the formation of the islands and implementation of the financial analysis;
- The methodology used to implement the CBA; and
- Discussion of the results of the analysis.

Figure 5.3 shows extracts from the Feasibility Study.

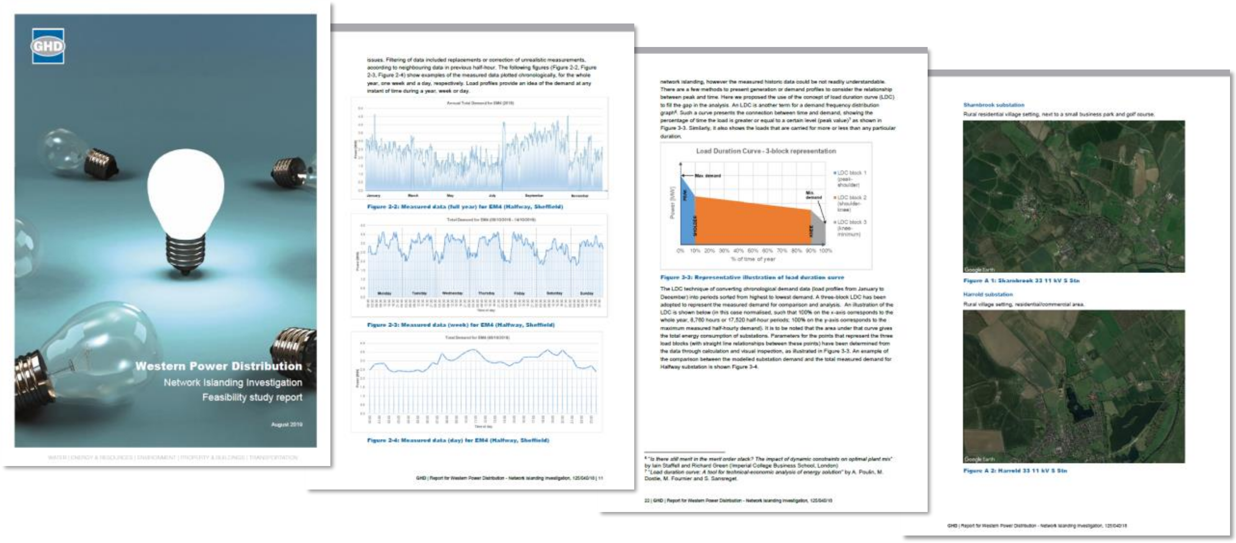

Figure 5.3 Extracts from the Feasibility Study

5.6 Further Investigation

The project team carried out further investigation work following completion of the Feasibility Study. The investigation focused on the following areas:

- Specific technologies to implement network islanding;
- The costs of implementing network islanding through engagement with equipment manufacturers;
- Refined estimates of financial, environmental and capacity benefits for customers, derived from results from system studies. This will provide a cost benefit analysis from the point of view of customers;
- Third party requirements (customers and generators);
- Ownership structures and operational responsibilities, including developments relating to DSO;
- Compatibility of network islanding with the regulatory framework; and
- Integration of network islanding with market, balancing and settlement mechanisms.

5.7 Network Modelling

This task involved developing network models in DIgSILENT Powerfactory power system analysis software for two trial areas. The models were built using existing databases such as the PSSE library, Geographic Information System (GIS), Long Term Development Statement (LTDS) and standard DIgSILENT generator libraries. The following studies were completed after model verification:

- Load Flow (loading, voltage, taps and losses);
- Fault Level (max and min fault levels); and
- Transient (line fault, generation trip, load rejection, switched-in load and fault clearance).

The studies confirmed that the two trial areas could be islanded and operate within the necessary standards and recommendations during steady state and fault conditions.

Figure 5.4 shows extracts from the Network Modelling exercise.

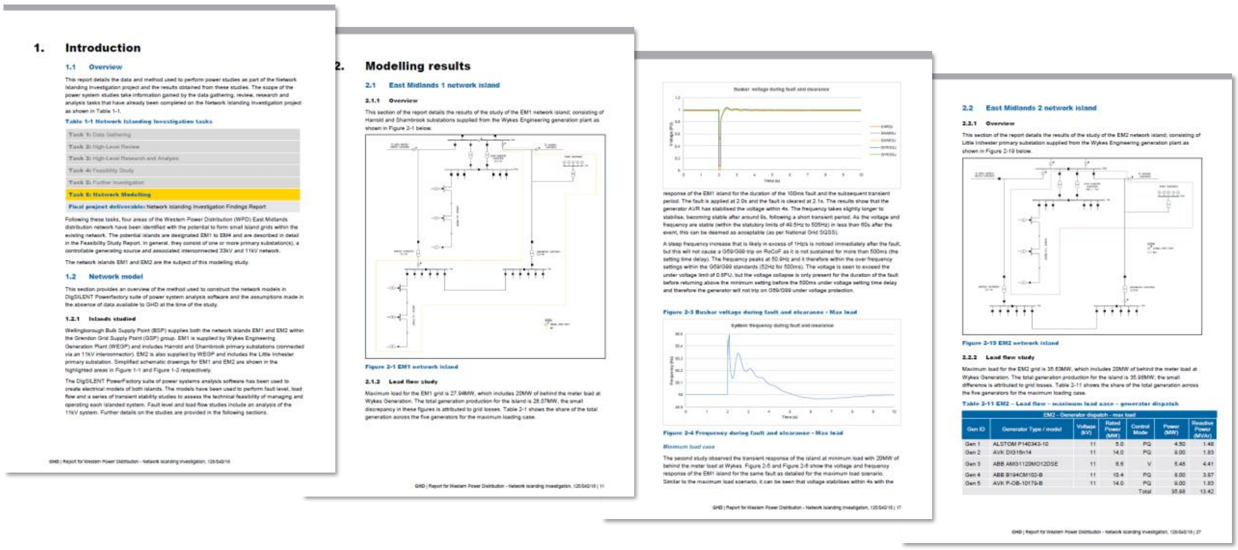

Figure 5.4 Extracts from Network Modelling

5.8 Investigation Findings Report

The Investigation Findings Report was the final deliverable in the Network Islanding Investigation Project and concluded the work to establish the technical, commercial, legal and regulatory feasibility of operating parts of the distribution network as an island.

The report provided further details on the technical elements of creating networks islands that were informed through detailed discussions with manufacturers. In particular, the report covered the protection and control requirements for operating and transitioning to/from the grid to a network island. It also considered the possible metering arrangements and impact on security of supply.

The legal and regulatory were further explored in this last phase with a focus on recent developments in charging mechanisms and outputs from projects such as the ENA's Open Networks Project. The review did not indicate any issues that would prevent a trial of network islanding, however, some minor modifications to the existing Elexon balancing and settlement system were identified.

Finally, the report finalised the commercial benefits of operating parts of the distribution network as islands. A top-down analysis was performed using Use of System (UoS) charges, estimated capital expenditure for facilitating the island and operational costs for the island. The analysis into the existing commercial frameworks and possible revenue streams for the trial areas revealed that it is difficult to achieve sufficient financial benefits. The cumulative NPV in 2039 was negative in all cases, with the highest NPV observed for the cases where islands are operated for a shorter duration in the year.

Figure 5.5 shows extracts from the Investigation Findings report.

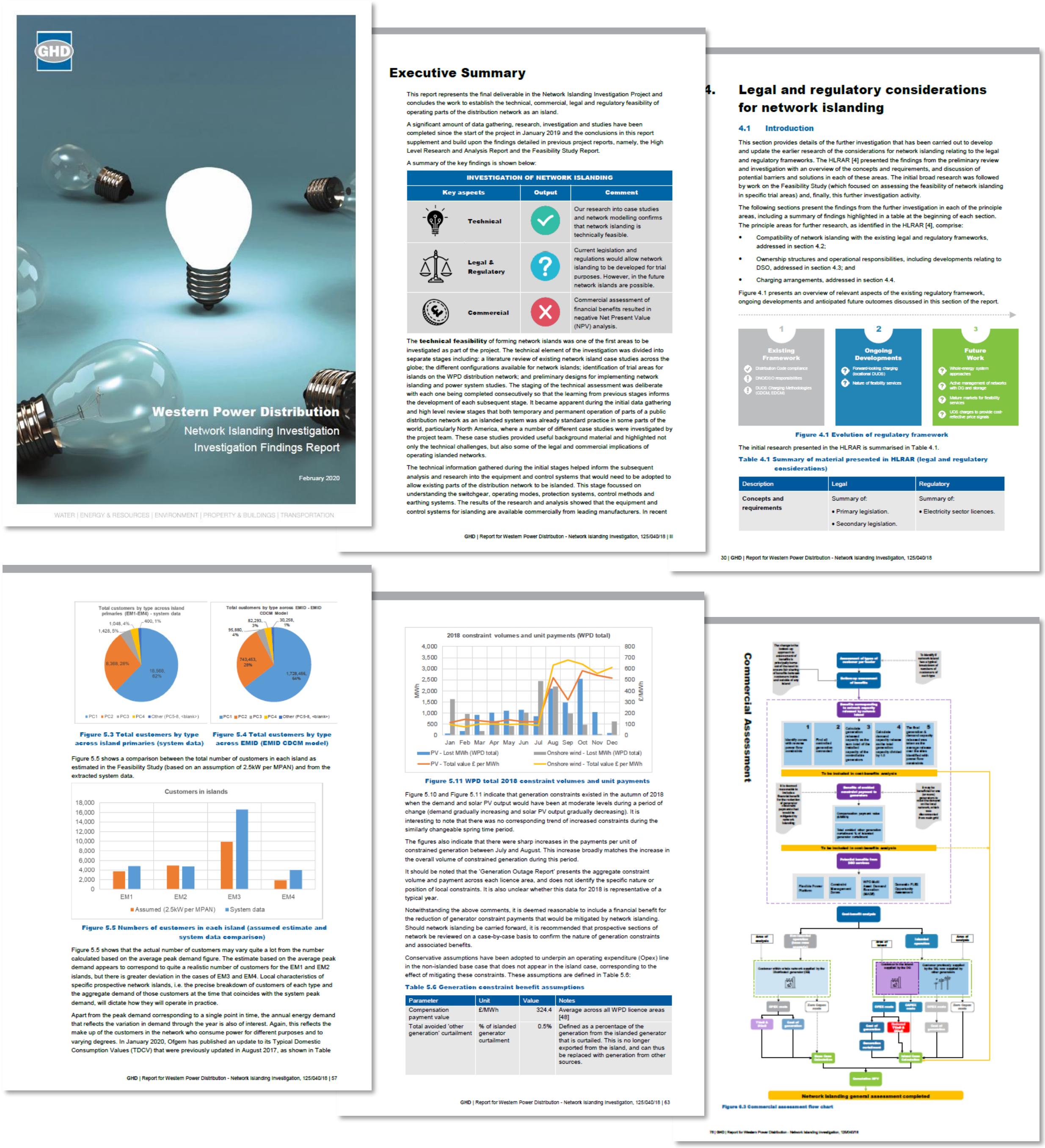

Figure 5.5 Extracts from the Investigation Findings report

6 Performance Compared to Original Aims, Objectives and Success Criteria

6.1 Overview

Network Islanding Investigation successfully delivered against all the original aims, objectives and success criteria that were set out at the start of the project.

The project found that DNOs would be able to intentionally island certain sections of the network in a safe and secure manner, however, the current commercial framework limits the financial benefits that can be achieved through islanding. The details contained within the various reports and material generated through this project provide valuable learning that should be revisited once there is further clarity on new and emerging commercial frameworks.

6.2 Project objectives

The project successfully met all the original objectives as detailed in Table 6.1.

Table 6.1 Project objectives

Objective	Status	Performance
Conduct desktop research to identify different suitable technical approaches to network islanding along with a preliminary assessment any current legal, regulatory or commercial barriers that exist and the costs and benefits of each approach	✓	Five technical approaches for implementing network islanding were captured and investigated within the High Level Review report. Thorough reesearch into legal, regulator and commercial barriers was presented and summarised in the high level research and analysis report.
Carry out a feasibility study that will identify suitable areas of WPD network that would benefit from the network islanding approaches	✓	The Feasbility Study identified multiple trial areas where network islanding could be implemented. The study also investigated the potential financial benefits that could be realised by implementing network islands.
Network modelling and analysis to demonstrate the operation of the islanding approaches and to quantify benefits	✓	The network modelling task successfully demonstrated that network islands could be formed and would be able operate within statutory limits. Transient studies also confirmed that the network islands would remain stable and respond appropriately for faults within the island.
Detailed investigation of the legal and regulatory issues that may impact the implementation of an islanded network and proposed solutions and revised methodologies to enable implementation	✓	The Investigation Findings report summarised the detailed research into the legal and regulatory issues that could effect network islanding. The report also highlighted the areas of the legal and regulatory frameworks that were being reviewed as part of the transition to DSO that would have a positive effect on network islanding.

Objective	Status	Performance
A final report that will present the findings of the investigation, including learning related to technology integration on the network and recommendations for further project development	✓	The Investigation Findings report summarised all the work that had been undertaken on the network islanding investigation project. The report finalised the main technical requirements and the areas where further clarity would be required before the project could be considered for a wide-scale trial. In addition, the report summarised the CBA for each of the trial areas.

6.3 Success criteria

The project delivered against the success criteria as detailed in Table 6.2.

Table 6.2 Project success criteria

Success criteria	Status	Performance
Review network island case studies from across the world and literature relevant to network islanding on distribution networks	✓	The High Level Review report provided a detailed literature review on the different types of islanded networks. A number of diffferent islanding concepts were investigated from Microgrids to virtual islanded networks. Several case studies from around the world were also studied and presetned within the report.
Understand if it is technically possible to implement network islanding on parts of WPD's distribution network and the equipment required to do achieve this	✓	The project included significant research and investigation into the technical requirements necessary for implementing network islands. The team engaged with several manufacturers to establish the equipment and systems that need to be installed on the network to operate and control the network island. Details of the equipment and systems are provided in the Feasibility Study and Investigation Findings report.
Review of the legal and regulatory requirements that could affect the implementation of the network islanding on distribution networks in GB	✓	The legal and regulatory requirements were studied in detail and summarised in the High Level Research and Analysis and Investigation Findings report. The findings highlighted that there were no specific legal or regulatory barriers. However, the work did identify a number of key areas that were currently under consultation (due to the need to transition to DSO) and this could help to promote islanding of networks in the future.
Analysis of the commercial considerations and implications of adopting network islands on the distribution networks in GB	✓	Detailed CBA was performed as part of the project and is fully detailed in the Feasibility Study (top-down analysis) and Investigation Findings report (bottom-up analysis).

Success criteria	Status	Performance
Dissemination of information, processes and learning that have been generated throughout the course of the project	✓	The Investigation Findings Report provides full details of the project scope, findings and recommendations. Learning has been captured throughout the project and is summarised in Section 9 of this Closedown Report.

7 Required Modifications to the Planned Approach during the course of the project

The planned approach was followed during the project and no significant modifications were made.

8 Project Costs

Activity	Budget	Actual
WPD Project Management	£37362	£17335
GHD Contract	£152046	£149088
Total	**£189408**	**£166423**

The actual project costs are lower than the budget due to the reduced project management costs which resulted from spending less time on the project than expected.

9 Lessons Learnt for Future Projects

The project team ensured that lessons from the project were captured on a monthly basis. Table 9.1 details the key learning that was generated from the project.

Table 9.1 Project learning

Item	Description
1	During the high-level review, a number of network islands have been identified that have already been put into operation, providing an understanding of the challenges and drivers for development. From the analysis of cases studies, it was observed that network islands could be classified into five main types depending on how the island interacts with the main grid, including microgrid, milligrid, remote power system, nanogrid and virtual microgrid or virtual power plant. ,
2	Development and operation of network islands are technically feasible, and the successful example can be found worldwide. There are various solutions for the control and protection of network islands, and the types of solutions are highly dependent on what equipment is already in operation on the network. The network island could operate in two states: grid-connected and island mode", therefore protection and control should be able to adapt to the settings.
3	During the feasibility study, it has been shown that financial benefits do not necessarily scale with the size of the island. In fact, several factors need to be considered to understand the financial benefits of a network island include: • Size of the island (number of customers, peak demand and annual energy demand); • Available generation capacity; • Current operating profile of the generator(s); • Net revenue associated with any curtailed generation from the generator(s); • Capital cost of new equipment for the new developments especially (these include the capital cost of a generating unit); and • Market and agreed contractual prices for energy.
4	During the course of the research, papers published by Ofgem and Elexon have been reviewed exploring the possibility of trailing innovative commercial arrangement arrangements. Ofgem's regulatory Sandbox provides an opportunity to perform a trial of an innovative market or business model in the electricity industry to demonstrate potential customer benefits. A similar feature was introduced by Elexon called "Electricity market sandbox" into Balancing and Settlement Code arrangements. It is important to notice that Ofgem confirmed that they would coordinate a common sandbox process across all Code Administrators who would like to participate.
5	The investigation of regulatory requirements in Distribution Code shows how network islanding can be achieved whilst ensuring that the existing standards of reliability and safety are maintained (i.e. adhering to the same obligations and requirements as a normally connected network). As such, technical requirements have been identified to mitigate any potential issues and ensure that islands can be operated in compliance with the Distribution Code.

Item	Description
6	A number of non-traditional commercial and regulatory arrangements for network islands has been researched and future activities could take a form of partnership with a supplier, where distributed generators are allowed to act as “lite” licensed suppliers, but they have to partner with existing fully-licenced suppliers to participate in industry codes on their behalf. Another possible future arrangement for islands could be “self-supply”, where a distributed generator would become a fully licenced electricity supplier or use private wire arrangements to allow a generator to supply power to neighbouring premises without transmitting through the public network.
7	During the engagement with various manufactures, the equipment and system requirements were explored in details. The majority of the manufactures have tried, tested and developed equipment, which is able to create and manage the utility-scale island. Key learning from the engagement is the fact that there is no “universal” solution for the specification and design of network island. Each potential island has different characteristics and requirements based on the existing equipment on the network, for example, number and type of generators in the island, a number of synchronisation points and network architecture. Each island requires detailed modelling, studies and analysis prior to committing resources for a real-world trial.
8	Network Modelling activities provided learning that fault level in island mode is significantly less compared with the grid-connected system. This was identified as a potential issue in work carried out during the earlier stages of the project. However, the system studies provided the necessary information to understand if protection discrimination was achievable and the indicative fault level values for the calculation of new protection settings.
9	Essential learning from Investigation Finding Report is the fact that the bottom-up assessment of potential benefits (financial benefits from capacity release and avoided constraint payments to generators) shows it is difficult to identify sufficient economic benefits to justify the capital investment to implement network islands. The NPV also decreases as the time in islanding mode increases due to the additional curtailment costs that occur. This means that the costs to implement network islands are not recovered from the derived benefits. Location-specific benefits and potential additional revenue streams should be reviewed again in 2-3 years.
10	The review of data received for generator output and demand measurements identified instances where power flow measurements are inaccurate or missing. The feasibility assessment of network islands relies heavily on the availability of accurate data. Without this data, it is difficult to assess if the island will work. Therefore, increased data availability and quality through half-hourly metering would improve understanding about the operation of the network and generation output and potential advantages of network islanding to provide flexibility

10 Outcomes of the project

10.1 Introduction

The Network Islanding Investigation project was delivered in four broad stages, with the findings from each stage presented in a report:

- **Stage 1 "High Level Review Report"** – This deliverable captured the results of a literature review that studied global case studies of network islands, identifying the technical requirements; the benefits and barriers to their implementation; and categorisation of their main use cases, or "approaches" for network islands. This Stage found that intentional islands were technical feasible and that there are a number of different motivations for implementing network islands; both of these findings were used to guide the study in the subsequent stages;
- **Stage 2 "High Level Research and Analysis Report"** – This presented the research into the legal, regulatory and commercial considerations for the approaches to network islanding identified in Stage 1. This Stage found that there were possible technical and environmental benefits for DNOs as well as commercial benefits for network customers when compared to the base case (i.e. non-islanded). This high-level analysis formed the basis for subsequent more detailed, targeted feasibility studies;
- **Stage 3 "Feasibility Study Report"** – This deliverable identified a number of trial area networks on the WPD distribution network, and then implemented a cost benefit analysis on each of the trial areas to quantify the benefit that islanding could yield for distribution network customers. This analysis found that there could be significant financial benefits, however, this was based on a number of assumptions and a more refined financial and technical model was required; and
- **Stage 4 "Investigation Findings Report"** – The final deliverable built on the work in Stage 3 to produce more detailed and robust financial and technical models of the trial areas. The cost benefit analysis was applied again based on these refinements, which led to detailed recommendations and conclusions on the feasibility of network islanding. Furthermore, power system studies were performed on the trial areas to understand the impact that islanding has on network load flows, fault levels and transient stability.

A brief overview of the key findings from the project are summarised in Figure 10.1 below. A detailed overview of the project outcomes are summarised in the following sections.

Key Aspects	Output	Comment
Technical		Our research into case studies and network modelling confirms that network islanding is technically feasible.
Legal and Regulatory		Current legislation and regulations would allow network islanding to be developed for trial purposes. However, in the future network islands are possible.
Commercial		Commercial assessment of financial benefits resulted in negative Net Present Value (NPV) analysis.

Figure 10.1 Summary of the key project findings

10.2 Technical outcomes

The technical requirements and technical feasibility for implementing network islanding was assessed throughout the project and significant technical knowledge and outcomes were found as part of the study. The main technical outcomes are summarised below:

The research and literature review in Stage 1 identified a number of key technical requirements for network islands, these were identified as follows:

- Protection systems may need to be re-designed due to reduced fault levels in islanded operation;
- Islanded networks have lower system inertia compared to interconnected networks making them more susceptible to voltage and frequency deviations;
- A control system is required to maintain stable operation of the island and to manage the disconnection and synchronisation of the island to the main interconnected grid; and
- The earthing system within the network island needs to be assessed due to possible disconnection of the earth circuit in island mode.

In Stage 3 of the project the study sought to set technical parameters for possible network islands so that a methodology could be generated to allow engineers to identify good candidate networks for future trials. The outcome of this work is summarised as follows:

- The island must have the capability to be isolated from the main interconnected system safely and without disruption to customers;
- Installed capacity of controllable generation must be greater than 150% of the peak demand in the island; and
- MW half-hourly data for the generation export and loads must be readily available for a minimum period of one year to allow an assessment to be completed.

A range of manufacturers were contacted in Stage 4 to understand the technical solutions the market is able to provide. The engagement also provided a more accurate estimate of the costs attributed to the design, development and installation of islanded networks on the distribution system. It was found that:

- The majority of the manufacturers have tried and tested equipment and systems that are able to create and manage utility scale islands;
- The larger manufacturers can implement turnkey solutions i.e. specification, detailed design, testing, installation and commissioning; and
- There is no ‘off-the-shelf’ solution for the specification and design of network islands: each island will have different requirements based on the existing equipment in the island; the number and type(s) of generation in the island; the number of synchronisation points; and the geography/architecture of the network.

A detailed power system study was undertaken on trial area networks in Stage 4 of the project. The trial area networks were modelled in the DIgSILENT Powerfactory suite of power system analysis software and a range of load flow, short circuit and transient studies were performed.

- The results showed that fault levels reduced significantly under islanded operation, however, this was expected as the contribution from the grid was no longer available;
- The studies showed that there is adequate headroom between the setting and load current for overcurrent discrimination purposes. The minimum headroom was classed as twice the minimum load current; and
- Transient study simulations showed the generator control system is able to react to transient events and voltage and frequency are stabilised.

Other general outcomes determined through the project are as follows:

- To enable a technically feasible, reliable and safe island a detailed protection study in the design phase of the project is required. This study will firstly identify the existing schemes, relay types and settings in the proposed network island. Secondly, the network will need to be modelled and a range of fault scenarios applied in order to understand the various fault levels (both grid connected and island modes). The design of new or modified schemes can then commence, using the network model as a tool to validate the new designs;
- The minimum loading of the network island needs to be taken into consideration in the network island design as the generator may not be able to supply this minimum load given its electrical and mechanical characteristics; and
- It cannot be assumed that a prospective island will improve electrical losses. This is because generation within an island can be large distances from the loads within the island. The island has to be modelled electrically and a calculation has to be carried out to confirm if there is a reduction in losses. If there is a reduction in losses, the reduction is small and therefore losses reduction is not a good motivation for implementing network islands.

10.3 Legal and regulatory outcomes

The study culminated in conclusions relating to the impacts of network islanding on: compatibility with the existing legal and regulatory frameworks; ownership structures and operational responsibilities, including developments relating to DSO; and charging arrangements.

There are currently no indications of anticipated changes to legal definitions or Distribution Licence Conditions. In addition, technical requirements have been identified to ensure compliance with the Distribution Code and the regulatory sandbox could support implementation of network islands to trial commercial arrangements under DCUSA. As a result, it is deemed that network islanding is compatible with the existing legal and regulatory framework.

It was concluded that refinements to DNO systems are likely to be made as part of the transition to the DSO role. It is anticipated that additional system functionality, as well as new contractual agreements, would enable DSOs to operate islands that make use of DG owned by third parties. A relatively minor modification to the existing settlement system has been identified (to ensure that correct energy volume data is transferred between parties), which could be used as a mechanism to support network islands. The current regulatory framework is considered to be unarguable and a technical solution could be implemented with control and monitoring capabilities such that DNOs would continue to comply with its obligations. In addition, use of network islanding as a substitute for flexibility services provided by others in the market has not been considered in order to meet the requirements of the regulatory framework relating to competition and fairness.

There is no indication that network islanding necessitates changes to the regulatory framework relating to technical operation of the network or ownership rules. Anticipated changes as part of the DSO transition are likely to complement islanding.

The study concluded that it would not be appropriate to reduce Use of System (UoS) charges for particular customers as a result of network islanding, but financial benefits should be shared between all customers. The existing charge calculation models that have been implemented according to the common distribution charging methodology (CDCM) would be adapted to account for cost reductions resulting from any such benefits.

In addition, ongoing external activities relating to charging arrangements are anticipated to complement network islanding. These initiatives are considering: development of markets for flexibility; making data available from half-hourly metering; and modification of charges to provide improved forward price signals, including locational charges.

10.4 Commercial outcomes

The commercial investigation concluded that, based on the analysis undertaken, the costs to implement network islands are not recovered from the derived benefits. This resulted in a negative cumulative NPV in all cases, which reduces for the cases where the islands are operated in islanded mode for longer periods. As such, network islanding is a more attractive solution for limited duration applications.

It may be possible to obtain additional revenues to make network islanding attractive for time-limited applications (in the order of £25,000 per year to achieve breakeven). However, it is not possible to definitively claim that these can be achieved. As such, it is recommended that the cost benefit analysis for network islanding should be reviewed again in 2-3 years to determine whether the relatively modest additional revenues can be achieved.

The study concluded that should a DNO identify potential additional revenues, the ability of particular network islands to earn these should be considered on a case-by-case basis prior to implementation. Prospective sections of network for islanding should be reviewed on a case-by-case basis to confirm the nature of specific reinforcement projects that may be avoided, local generation constraints and associated benefits[1]. The assessment should consider the potential impact on the competitive market for DSO services if substitution of flexibility services provided by third parties is to be considered.

Finally, the study concluded that prior to implementation of any islands it would be in the interest of the DNO to undertake an assessment of the numbers of customers and breakdown of types of customers within prospective islands. No particular issues have been identified in this regard, but this is recommended to confirm that no operational issues would be expected to arise, or potential impacts on cost recovery.

[1] The conclusions made in this project are based on identified estimates for the anticipated benefits associated with capacity release and mitigation of local generation constraints

11 Data Access Details

The deliverables and associated information for the Network Islanding Investigation project have been published on our innovation website.

Table 11.1 provides links to the deliverables that have been published.

Table 11.1 Links to project deliverables

Deliverable	Link
High Level Review	https://www.westernpower.co.uk/downloads/115369
High Level Research and Analysis	https://www.westernpower.co.uk/downloads/55615
Feasibility Study	https://www.westernpower.co.uk/downloads/55618
Investigation Findings Report	https://www.westernpower.co.uk/downloads/113395

12 Foreground IPR

No foreground IPR has been developed as part of this project.

13 Planned Implementation

The project has carefully studied and examined the technical, legal, regulatory and commercial aspects of operating part of the distribution network as an island. Despite the results showing that it is possible to island parts of the distribution network from technical and legal / regulatory perspective, the investigation into the existing commercial frameworks and possible revenue streams has shown that it is difficult to achieve sufficient financial benefits. This means that the costs to implement network islands are not recovered from the derived benefits. Therefore, it is not planned to implement network islanding as potential solution to provide benefits to customers.

However, as the energy markets and commercial frameworks are continuing to change, it is recommended that location-specific benefits and potential additional revenue streams should be reviewed again in 2-3 years.

14 Other Comments

Not applicable.

15 Contact

Further details on the project can be made available through the contact information below:

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Glossary

Acronym	Definition
CBA	Cost Benefit Analysis
CDCM	Common Distribution Charging Methodology
DCUSA	Distribution Connection and Use of System Agreement
DG	Distributed Generation
DNO	Distribution Network Operator
DSO	Distribution System Operator
GB	Great Britain
GIS	Geographic Information System
IPR	Intellectual Property Rights
LTDS	Long Term Development Statement
MW	Mega Watt
NIA	Network Innovation Allowance
NPV	Net Present Value
UoS	Use of System

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