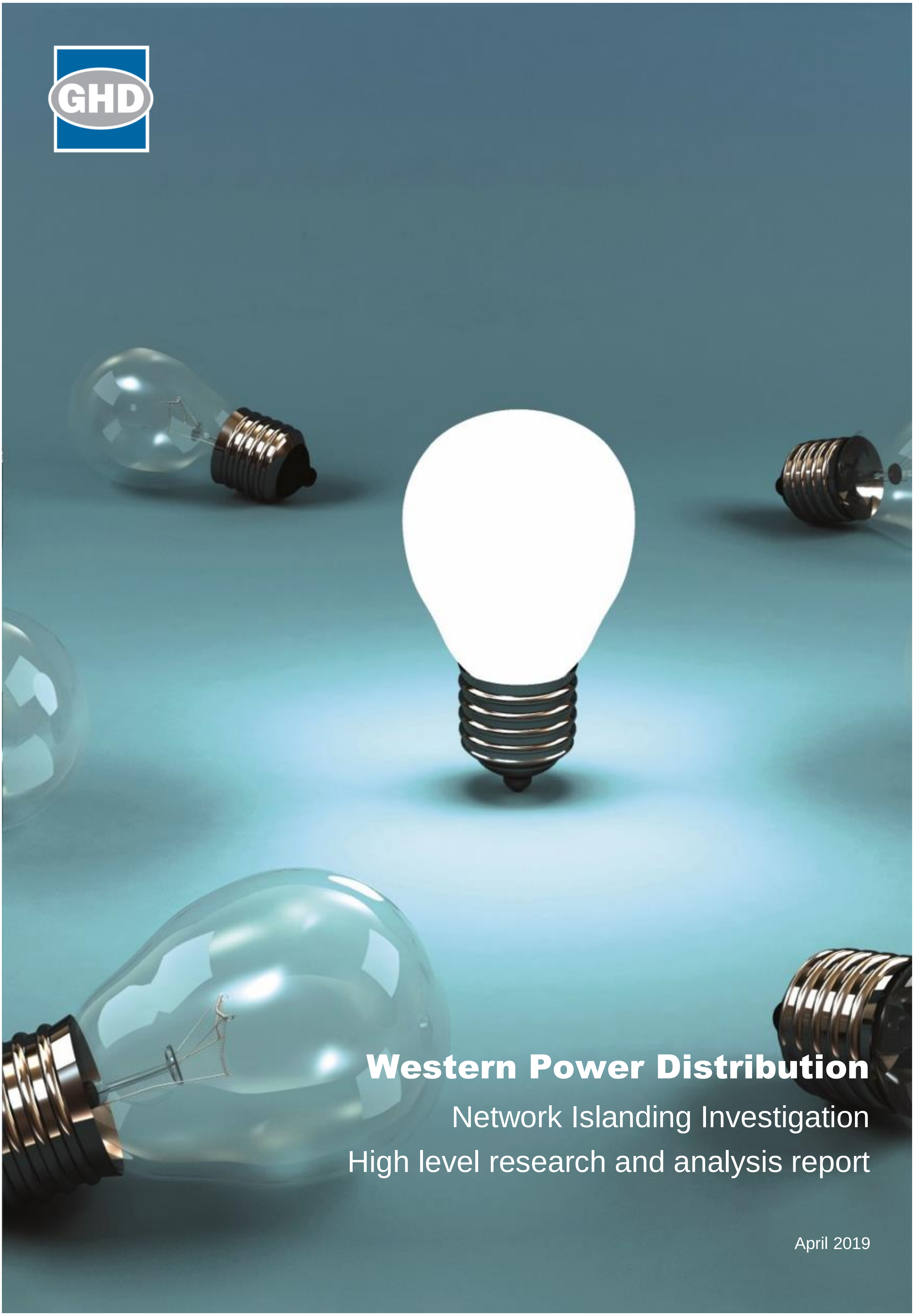

Western Power Distribution

Network Islanding Investigation

High level research and analysis report

April 2019

Glossary

Acronym	Definition
AC	Alternating Current
BCA	Bilateral Connection Agreement
BEGA	Bilateral Embedded Generation Agreement
BEIS	Department for Business, Energy and Industrial Strategy
BESS	Battery Energy Storage System
BETTA	British Electricity Trading and Transmission Arrangements
BM	Balancing Mechanism
BMRA	Balancing Mechanism Reporting Agent
BSC	Balancing and Settlement Code
CAF	Cost Apportionment Factor
CCCM	Common Connection Charging Methodology
CDCA	Central Data Collection Agent
CDCM	Common Distribution Charging Methodology
CEPA	Cambridge Economic Policy Associates
CHP	Combined Heat and Power
CI	Customer Interruptions
CIRED	International Conference on Electricity Distribution
CM	Capacity Market
CML	Customer Minutes Lost
CUSC	Connection and Use of System Code
CVA	Central Volume Allocation
DC	Direct Current
DCUSA	Distribution Connection and Use of System Agreement
DDRC	Distribution Data Registration Code
DECC	Department of Energy and Climate Change
DER	Distributed Energy Resources
DG	Distributed Generator
DGC	Distribution General Conditions
DGD	Distribution Glossary and Definitions
DIN	Distribution Code Introduction
DNO	Distribution Network Operator
DOC	Distribution Operating Code
DPC	Distribution Planning and Connection Code
DSO	Distribution System Operator
DSR	Demand Site Response
ECEEE	European Council for an Energy Efficient Economy
ECVAA	Energy Contract Volume Aggregation Agent
ECVNA	Energy Contract Volume Notification Agent
EHV	Extra high voltage
ENA	Electricity Networks Association
EPR	Electronic Public Register
EPS	Electronic Power System
EREC	Engineering Recommendation
ESO	Electricity System Operator
ESQCR	Electricity Safety Quality and Continuity Regulation
EU	European Union
FAA	Funds Administration Agent
FCP	Forward Cost Pricing
FP	Framework Program
GB	Great Britain
GEMA	Gas and Electricity Markets Authority
GHG	Greenhouse Gases

Acronym	Definition
HH	Half Hourly
HHS	Half Hourly Settlement
HV	High Voltage
IPP	Independent Power Producer
LCT	Low Carbon Technology
LDNO	Licensed Distribution Network Operator
LRIC	Long Run Incremental Cost
LV	Low Voltage
MVA	Mega Volt Ampere
MW	Mega Watt
NETA	New Electricity Trading Arrangements
NETSO	National Electricity Transmission System Operator
NHH	Non-Half Hourly
OFFER	Office of Electricity Regulation
OFGEM	Office of Gas and Electricity Market
OHL	Overhead Line
OTSO	Offshore Transmission System Operator
PCC	Point of Common Coupling
PV	Photovoltaic
RES	Renewable Energy Sources
RIIO	Revenue = Incentives + Innovation + Outputs
RPI	Retail Price Index
SAA	Settlement Administration Agent
SB	Senator Bill
SCADA	Supervisory Control And Data Acquisition
SVA	Supplier Volume Allocation
SVAA	Supplier Volume Allocation Agent
TSO	Transmission System Operator
VPP	Virtual Power Plant
WPD	Western Power Distribution

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Appendices

Appendix A – Gantt Chart
Appendix B – High level review report

1. Introduction

1.1 Context of project

Around the world, low carbon technologies have led to a trend of generating power locally to customers from distributed generation (DG) connected to the distribution system, including renewable energy resources. Due to rapid demand growth, the system requires an increasing amount of generation. Enhanced use of renewable generators within distribution networks calls for a growing level of network flexibility, whilst control the existing standard for safety. It is expected that the utilisation of distributed energy resources (DER) would support to generate low carbon power with much lesser environmental impact and lower costs for customers.

Islanding of Distributed Generators under current practice should be avoided. Typical safety schemes for DG include under/over voltage and under/over frequency protection, which prevent continued supply to customers in an islanded section of the network. In addition, Loss of Grid protection ensures that disconnected circuits remain de-energised and thus enabling a safe and secure network.

The network islanding project aims to investigate whether intentional islanding of certain sections of network would allow them to be operated in a safe and secure manner, and whether this represents a new tool for DNOs to increase network flexibility. The theory is that network islanding could provide significant benefits for customers and support DNOs with the transition to DSO.

1.2 The aim of this report

This high-level research and analysis report intends to explore the considerations for network islanding that were not considered in the high-level review, namely those relating to: legal; regulatory; and commercial aspects. The report presents research of the concepts and requirements; barriers and possible solutions for each of the islanding approaches. It also provides an assessment of the feasibility of the approaches; and high level commentary on the considerations for the feasibility study to be prepared during subsequent phases of the project.

1.3 Tasks and deliverables

Table 1-1 highlights task 3 of the Network Islanding Investigation project, which is the subject of this report.

Table 1-1 Network Islanding Investigation tasks

Task 1: Data Gathering
Task 2: High-Level Review
Task 3: High-Level Research and Analysis
Task 4: Schedule of Requirements
Task 5: Detailed Research and Analysis
Task 6: Detailed Modelling
Final project deliverable: Network Islanding Investigation Findings Report

The information provided in this report will be used to inform the subsequent detailed research and analysis phase of the project. In addition, the relevant research from this document will be summarised for publication in the close down report of the Network Islanding Investigation project.

2. Summary of the high-level review report

2.1 Introduction

This section provides an overview of the high-level review report produced in Task 2 of the project. The full high-level review report is provided in Appendix B.

The content of the high-level review report consisted of identification and review of network islanding approaches from international literature. The high-level assessment was accomplished through the review of existing examples of successful islanding of network systems from several research documents. In the previous report, various case studies were presented to support analysis of latest islanding approaches, including technological consideration of implementing and safe operation of islanded distribution network with DGs. Several benefits and barriers to islanding were included and discussed within the high-level review. The initial assessment of findings, network islanding, could be technically feasible within current and proven practice around the world.

2.2 Primary concepts of network islanding

The typical GB electricity grid is centralised with large power plant generating electricity and transmitting over long distances on a high voltage transmission network to distribution centres. Substations at the centres transform high voltage down to medium and low voltages to supply power to industrial, commercial and domestic customers via the distribution system. Traditionally, the distribution network has been a passive system and connecting the transmission network down to customer loads. With currently increasing number of DGs connected at a medium and low voltage level and rapid changes in demand patterns caused by electrification of transport and heat, the distribution network will experience more bidirectional power flow. Consequently, DNOs expressed a need for a sustainable and safe solution to accommodate these changes. A term “network island” describes a section of the distribution network, which contains demand and generation (DGs) and has an ability to operate connected or isolated from the main interconnected network. The key aspect of islands is ensuring safe, controlled and coordinated operation of the whole system including loads, generators, storage facilities and protection devices. During the literature review, many examples and research were found covering the design and operation of islands. Additionally, a number of network islands topologies were established and classified:

- Microgrids;
- Milligrids;
- Remote power system;
- Nanogrids; and
- Virtual microgrids or virtual power plants.

2.3 Islanding technological considerations

Technological requirements and barriers were presented in this section and introduce a comprehensive outline of existing and emerging technologies. The key concerns arise from multiple operation modes of network islands. The network could be islanded and operated physically isolated from the main network, as well as in parallel with the main network. An innovative concept is operation in “virtual island mode” with zero transfer of power across the physical boundary without isolation.

Another key elements from the technical considerations was the protection system which must ensure safe operation during various modes and transition between them. A possible solution can be found throughthe application of adaptive protection, which provides a solution that can maintain the sensitivity and selectivity of the network protection whether it is operated in grid-connected or islanded mode. Other examples of protection systems that were investigated as part of the high-level review included:

- Voltage protection for network islands with high penetration of inverter-based generation;
- Differential protection scheme for microgrid feeder and bus-bar, which provide selectivity and high level of sensitivity for internal faults in both grid-connected and islanded modes;
- Distance protection that measures current and voltage protection from relay location to calculate the impedance of the line it is protecting;
- Utilising external devices that can increase the fault level contribution; and
- Travelling wave protection for inverter dominated microgrids.

An isolated part of the distribution network tends to be weaker, suffer from low system inertia and can be affected by frequency and voltage distributions. Under these conditions, the safe and stable operation of the island strongly depends on a control system and strategies implemented by specific controller devices. According to reviewed literature, network islands are typically controlled in a hierarchical approach similar to the traditional electricity grid with generating plants. The hierarchy of control level differs in terms of their response time and communications requirements:

- Primary control - control that has the fastest response actions within the island and performs load sharing among DG units;
- Secondary control – performs corrective action to remove the frequency and voltage deviation that occurs after the first level of control actions; and
- Tertiary control – the high-level control system that manages the flow between the island and the mains.

In the same manner, DG control could be split into two categories of communication and non-communication based methods, which includes the well-known droop control of generators. The advantage of droop control is that load sharing between DG sources can take place without the need for any communications between DG. The communication-based methods can be sub-divided according to primary control of network islands:

- Centralised control;
- Decentralised control; and
- Master-slave control.

From the literature analysis, decentralised control has gained less focus as generally centralised control is easier to implemented and operated.

In the high-level study, the transition between “island” and “non-island” mode was investigated and consideration was given between both planned and unintentional islanding of network. of the investigation found that sustaining supplies to an island network during disconnection from the main network is susceptible to the voltage and frequency stability during the transition, which is determined by balancing load and generation within the island. Subsequently, re-synchronisation with grid after disconnection might be facing challenges from, for example, controlling generating devices with various control schemes. Two technologies presented in the previous report are able to overcome this issue, these were advanced automatic synchronisers or advanced synchronism-check relays.

The last aspect considered was suitable earthing of generating plant and associated equipment connected to the network. This consideration is crucial to provide safety for customers and operational staff and to reduce the probability of damage during fault situations. Generally, the high-voltage distribution network in Great Britain is earthed at the source; therefore, a network operating as an island might be isolated from the this source. The alternative solution that facilitates the necessary path for earth fault current is to provide a local earth source through connection of the DG start point to earth through an appropriately rated impedance or zig-zag earthing transformer inside the islanded network.

2.4 Issues, drivers and identification of islanding approaches

This section begins by describing the various high-level network issues that may be addressed by islanding solutions. These issues led to drivers for network islands application and the primary benefits that they could provide. The following issues and drivers in Figure 2-1 were identified during the literature review and case study analysis.

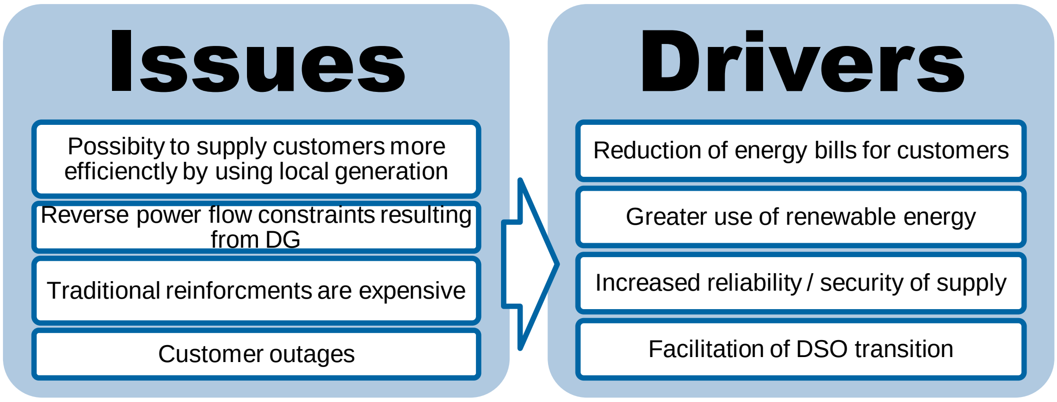


Figure 2-1 Identified issues that can be addressed by network island and suitable drivers.

The issues described highlight the challenges that electricity network operators are currently facing. From this, drivers were established and which aim to reflect the principal benefits for the application of islanding strategies. They have been selected to take account of the latest requirements for network innovation, future system operation and competitive markets trend. The described network islanding approaches are:

- **Islanding to enable greater use of renewable energy resources** – due to the increasing number of DG connected to the distribution level, the network is experiencing more reverse power flow, and voltage constrains. Those constrains limits further connection of new DG. As a result, network islanding has been found to be an alternative solution to assist the reduction of reverse power flow through the local balancing of demand and generation and therefore releasing network capacity for DG connections. Removing barriers to the connection of new renewable generation capacity is expected to be a significant capacity and carbon benefit of network islanding.
- **Islanding to increase the security of supply** – consideration of ensuring the continuous and uninterrupted supply has been recognised as the most common motivation for the implementation of network islands. There are many examples of institutions, which operate as network islands, such as university campuses, military bases and prisons; their supply is usually grid-connected but is able to transfer to islanded operation using backup supplies to provide high quality secure electrical energy during severe weather events or natural disasters that may affect the main network.
- **Islanding as an alternative to traditional network reinforcement** – provides DNO with a potential solution to defer or avoid high-cost traditional network reinforcement that is

used to mitigate thermal and voltage constraints. Figure 2-2 and Figure 2-3 illustrate the principles of this approach.

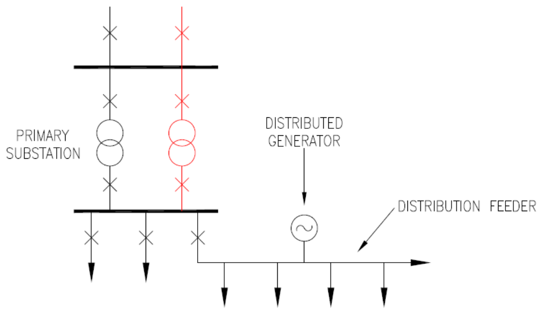


Figure 2-2 Substation with traditional reinforcement to comply with the security standard

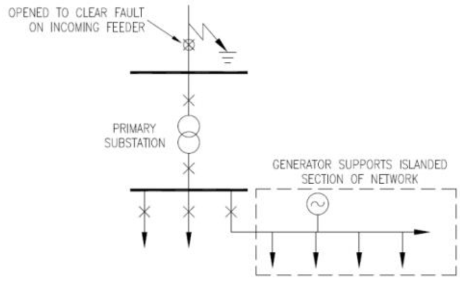


Figure 2-3 Islanded section of distribution feeder

- **Islanding to reduce other costs** – the approach explores the potential of network island to provide financial savings to electricity customers within a network island boundary by lowering their utility bills. The idea involves minimising the energy imported from the main grid network, in addition to the profit gained from the exporting excess generation from the island to the main utility. When the network is in the island mode of operation it is a requirement that the demand is balanced with generation locally; hence the customers within the island are notionally utilising a smaller proportion of the transmission and distribution infrastructure than they otherwise would do when connected to the main network. Consequently, an argument can be made for the reasonable apportionment of lower use of system charges to those customers within the island.
- **Islanding as a tool for operating networks with greater flexibility and resilience** – due to significant changes to the traditional electricity network, penetration of DG, storage devices, further electrification of heat and transport and low carbon technologies are predicted to increase rapidly. As the response to these advances, DNOs transforming from traditional network operators to distribution system operators (DSOs). The previous report has identified that intentional network islanding is a new method/technique that can be utilised as flexibility service to assist the DSO in the operation of its network. If the network island is owned and operated by the DSO, it can be disconnected and reconnected at will to provide a range of possible functions.

2.5 Aspects of network islanding and assessment of approaches

Following a number of motivations and approaches recognised in the previous section, customer's requirements and possible benefits were classified according to the ability to address modern electricity industry challenges. Drivers behind network islanding development differ depending on customers involved in the project, and benefits, which stakeholder would like to achieve. The list of main benefits of islanding includes topic from the financial sector, customer perspective, commercial and DNO concerns, as following:

- Increased use of distributed renewable energy generation;
- Increase security/reliability of supply;
- System flexibility;
- Reducing of other costs;

- Avoidance of reinforcements;
- Promotion of sustainable behaviours.

In the same manner, the identification of barriers for network islanding gives a comprehensive overview of the innovation project analysis. The selected barriers are grouped into four main categories:

- Engineering (for example frequency voltage control and power quality issues)
- Commercial (for example investments costs associated with infrastructure and technologies)
- Regulatory (for instance lack of technical guidelines and inadequacy of existing regulation)
- Others (cybersecurity issue)

As the next section of the high-level report, for the process of selecting appropriate approaches to be taken forward, there are several factors, which should be considered. These factors included both the requirements for the industry and customers. Each of the approaches identified has the potential to provide varying levels of benefits across different areas. In summary, network islanding was recognised as a technically viable alternative for a DNO/DSO to release financial, carbon and capacity benefits.

3. Research of legal considerations of network islanding

3.1 Introduction

The following section investigates legal requirements in Great Britain and considers the impact of these requirements on network islanding. A review of primary and secondary legislation is presented followed by a discussion on the potential barriers and solutions.

3.2 Concepts and requirements

The operation of the electricity sector, and the variety of organisations within it, falls under the rules set in primary and secondary legislation, as well as industry codes developed under responsibilities appointed by legislation. Figure 3-1 presents an overview of the hierarchy of documents that represent the governance framework for the sector.

The legislation has developed through time, but the research presented in this report focuses on the Electricity Act 1989 (which set the framework for the liberalisation and privatisation of the sector) and subsequent developments. Separate provision has generally been made for the Northern Ireland electricity sector due to its detachment from the system in Great Britain, and proximity to that of the Republic of Ireland. In addition, there are instances where the sector in Scotland is treated differently from that in England and Wales. This research does not include detailed study of such differences, but strives to reflect the prevailing legal framework for WPD operating networks in England and Wales.

In addition, EU legislation has a direct effect on GB regulation and, in many cases, the UK's acts refer to EU Directives [1] [2] [3]. It is well known that the European Parliament has strong support for renewable energy and mitigation of carbon emissions. In order to promote these, targets are set for the levels of greenhouse gas emissions and increasing energy efficiency. The links between UK and EU legislation, and possible changes to them in future, have not been included in the high level research presented in this report.

The principal UK primary legislation concerning the electricity sector comprises the following, which are summarised in sub-section 3.2.1:

- Electricity Act 1989 (c. 29) [1];
- Utilities Act 2000 (c. 27) [3];
- Energy Act 2008 (c. 32) [4];
- Energy Act 2010 (c. 27) [2];
- Energy Act 2011 (c. 16) [5];
- Energy Act 2013 (c. 32) [6]; and
- Energy Act 2016 (c. 20) [7].

The following principal pieces of secondary legislation have been identified as being relevant to the regulatory and licensing framework in which DNOs operate. These statutory instruments must be observed if DNOs wish to implement network islanding, and are summarised in sub-section 3.2.2:

- The Electricity (Class Exemptions from the Requirement for a Licence) Order 2001 (S.I. 2001 No. 3270) [8];

- The Electricity Safety, Quality and Continuity Regulations 2002 (S.I. 2001 No. 2665) [9], referred to as ESQCR;
- The Electricity (Class Exemptions from the Requirement for a Licence) (Amendment) Order 2005 (S.I. 2005 No. 488) [10];
- The Electricity and Gas Appeals (Designation and Exclusion) Order 2009 (S.I. 2009 No. 648) [11];
- The Electricity (Applications for Licences, Modifications of an Area and Extensions and Restrictions of Licences) Regulations 2010 (S.I. 2010 No. 2154) [12];
- The Electricity and Gas (Internal Markets) Regulations 2011 (S.I. 2011 No. 2704) [13]; and
- The Electricity and Gas Appeals (Designation and Exclusion) Order 2014 (S.I. 2014 No. 1293) [14].

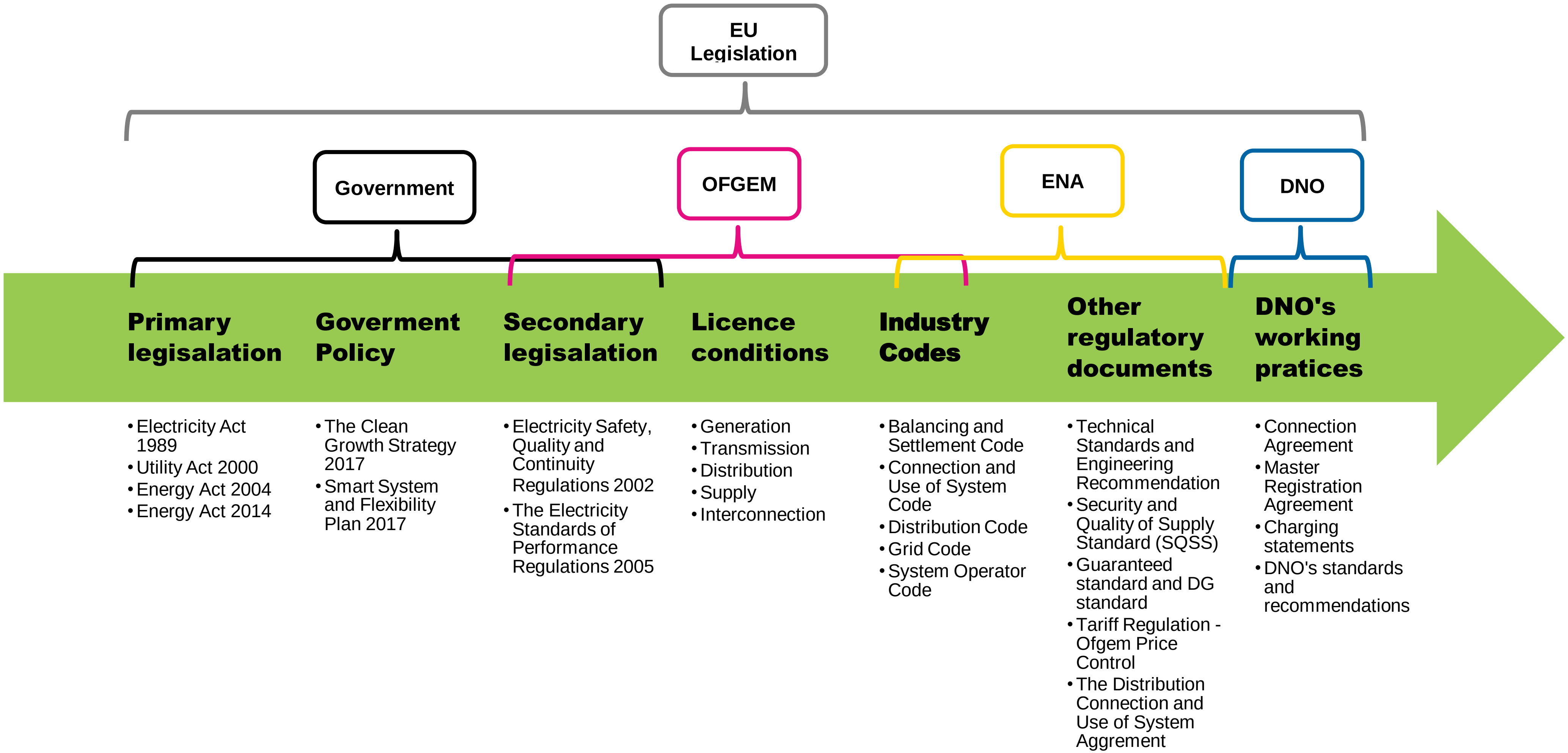


Figure 3-1 Overview of sector governance

3.2.1 Primary legislation

Electricity Act 1989

This Act, enacted on 27 July 1989, sets out the framework for the privatisation and liberalisation of the electricity industry in GB. Although subsequently amended, with significant changes made through enactment of the Utilities Act 2000 (discussed below), it was initially drafted to 'provide for the appointment and functions of a Director General of Electricity Supply and of consumers' committees for the electricity supply industry'. The creation of the Director General 'led to the formation of Ofgas, the Office of Gas Supply, and OFFER, the Office of Electricity Regulation' [15] which were later merged to form Ofgem, the Office of Gas and Electricity Markets.

Section 3 of the Act places responsibilities on the Secretary of State and the Director General:

'**3 General duties of Secretary of State and Director**

(1) The Secretary of State and the Director shall each have a duty to exercise the functions assigned or transferred to him by this Part in the manner which he considers is best calculated—

(a) to secure that all reasonable demands for electricity are satisfied;

(b) to secure that licence holders are able to finance the carrying on of the activities which they are authorised by their licences to carry on; and

(c) subject to subsection (2) below, to promote competition in the generation and supply of electricity.

…

(3) Subject to subsections (1) and (2) above, the Secretary of State and the Director shall each have a duty to exercise the functions assigned or transferred to him by this Part in the manner which he considers is best calculated—

(a) to protect the interests of consumers of electricity supplied by persons authorised by licences to supply electricity in respect of—

(i) the prices charged and the other terms of supply;

(ii) the continuity of supply; and

(iii) the quality of the electricity supply services provided;

(b) to promote efficiency and economy on the part of persons authorised by licences to supply or transmit electricity and the efficient use of electricity supplied to consumers;

(c) to promote research into, and the development and use of, new techniques by or on behalf of persons authorised by a licence to generate, transmit or supply electricity;

(d) to protect the public from dangers arising from the generation, transmission or supply of electricity; and

(e) to secure the establishment and maintenance of machinery for promoting the health and safety of persons employed in the generation, transmission or supply of electricity; and a duty to take into account, in exercising those functions, the effect on the physical environment of activities connected with the generation, transmission or supply of electricity.

Electricity Act 1989, section 3

This Act established the licensing regime as follows:

'(1) The Secretary of State after consultation with the Director… may grant a licence authorising any person—

(a) to generate electricity for the purpose of giving a supply to any premises or enabling a supply to be so given;

(b) to transmit electricity for that purpose in that person's authorised area; or

(c) to supply electricity to any premises in that person's authorised area.'

The Electricity Act 1989 (c. 29), section 6(1)

This Act also made provision for the necessary transfers to the newly licensed private sector companies by 'the vesting of the property, rights and liabilities of the Electricity Boards and the

Electricity Council in companies nominated by the Secretary of State and the subsequent dissolution of those Boards and that Council'. As such, this Act remains in force as the foundational legislation that governs the activities of all current generation, distribution and transmission network owners and operators, as well as supply companies. The Act provides separation of operational functions of the industry.

Section 4(1) of the Act is titled 'Prohibition on unlicensed supply etc.' and makes it an offence to undertake any of the licensed activities without a licence or licence exemption. Section 5(1) states that the Secretary of State may grant exemptions to generators or suppliers to operate without a licence with specified conditions. The exemptions can be awarded 'to persons of a particular class; or to a particular person' [16].

Section 9 of the Act sets down the obligations and duties of licence holders, including electricity distributors.

9 General duties of licence holders

'(1) It shall be the duty of an electricity distributor—

(a) to develop and maintain an efficient, co-ordinated and economical system of electricity distribution;

(b) to facilitate competition in the supply and generation of electricity.'

Electricity Act 1989, section 9

The Electricity Act 1989 as well as the Gas Act 1986, the Utility Act 2000, the Competition Act 1998, the Enterprise act 2002 and the Energy Acts of 2004, 2008, 2010 and 2011 etc. have set out power and duties of the Gas and Electricity Markets Authority, referred as GEMA.

Utilities Act 2000

This Act, enacted on 28 July 2000, in Part I (New regulatory arrangements) made provision for the establishment and functions of the Gas and Electricity Markets Authority (GEMA) to take over the functions of the Director General of Electricity Supply. The creation of GEMA was followed by the merging of the Office of Electricity Regulation (OFFER) and the Office for Gas Supply (Ofgas) to form the Office for Gas and Electricity Markets (Ofgem) that is governed by GEMA.

Section 68 of this Act (Modification of licences: electricity trading arrangements) provides a new inserted section 15A (Licence modifications relating to new electricity trading arrangements) to the Electricity Act 1989. These new arrangements, referred to as NETA, are described in sub-section 4.2.2.

Section 30 of this Act is a notable amendment to section 6 of the Electricity Act 1989 in that it transfers the power to '…grant a licence authorising any person to supply electricity to any premises specified or of a description specified in the licence;…' from the Secretary of State to GEMA, and adds provision 2 below:

(1) The Authority may grant any of the following licences—

(a) a licence authorising a person to generate electricity for the purpose of giving a supply to any premises or enabling a supply to be so given ("a generation licence");

(b) a licence authorising a person to transmit electricity for that purpose in that person's authorised area ("a transmission licence");

(c) a licence authorising a person to distribute electricity for that purpose ("a distribution licence"); or

(d) a licence authorising a person to supply electricity to premises ("a supply licence").

(2) The same person may not be the holder of both a distribution licence and a supply licence

Utilities Act 2000, section 30

Energy Act 2004

This Act, enacted on 22 July 2004, includes provisions for the following :

- For the 'development, regulation and encouragement of the use of renewable energy sources';

Part 2, chapter 4 of the Act makes some amendments to section 32(3) of the Electricity Act 1989 relating to the renewables obligations.

- 'In connection with the regulation of the gas and electricity industries';

Part 3 (Energy Regulation), chapter 1 (Electricity trading and transmission) makes provision for the 'new arrangements relating to the trading and transmission of electricity in Great Britain', i.e. connected with the introduction of the BETTA arrangements which extend NETA to cover Scotland.

Energy Act 2008

This Act, enacted on 26 November 2008, includes provisions for the following:

- in relation to electricity generated from renewable sources;
- about payments to small-scale generators of low-carbon electricity;

Part 2 (Electricity from renewable sources) of this Act makes some further substitutions for sections 32-32C of the Electricity Act 1989 relating to the renewables obligation.

It also makes provision for 'power to amend licence conditions' relating to feed-in tariffs, as well as provisions regarding offshore transmission.

Energy Act 2010

This Act, enacted on 8 April 2010, includes provisions related to reduction of greenhouse gas emissions and use of carbon capture and storage technology. However, no provisions directly relevant to network islanding have been identified.

Energy Act 2011

This Act, enacted on 18 October 2011, includes provisions related to energy efficiency improvements, and the requirement for GEMA prepare an annual reports on security of energy supplies. However, no provisions directly relevant to network islanding have been identified.

Energy Act 2013

This Act, enacted on 18 December 2018, includes provisions for the following:

- for or in connection with reforming the electricity market for purposes of encouraging low carbon electricity generation or ensuring security of supply;

In Part 2 (Electricity Market Reform), this act introduced provisions for:

- Chapter 2 - Contracts for Difference (CfD), with the objective to 'provide long-term revenue stabilisation for new low carbon initiatives'.
- Chapter 3 - Capacity Market (CM), with the objective to 'ensure security of electricity supply at the least cost to the consumer' [17].

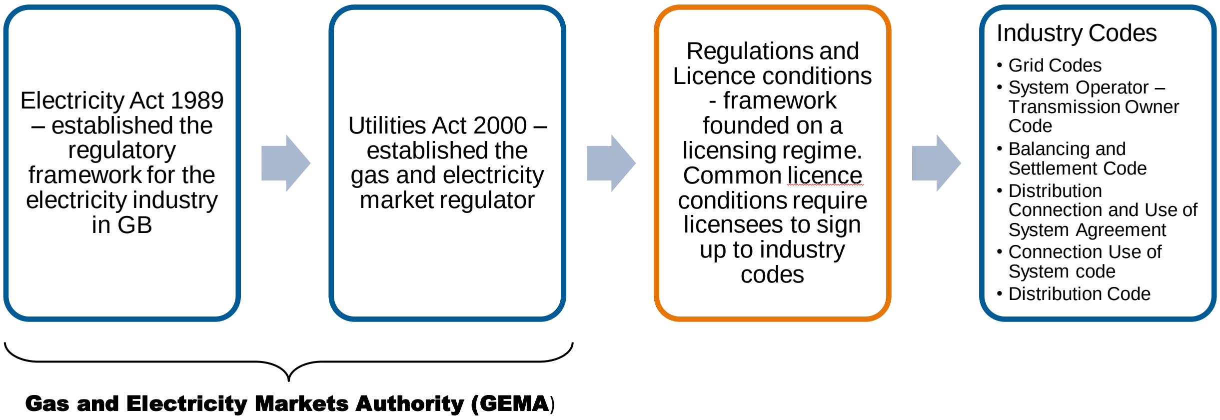
- for extending categories of activities for which energy licences are required;

In Part 2, Chapter 5 (Conflict of interest and contingency arrangements), this act introduced provisions for regarding modifications of transmission and other licences for the purpose of separating the system operator functions from other functions of business in the electricity sector.

Energy Act 2016

This Act, enacted on 12 May 2016, principally makes provisions relating to regulation of the oil and gas sector, and is not relevant to islanding.

3.2.2 Secondary legislation



The Electricity (Class Exemptions from the Requirement for a Licence) Order 2001

In the following schedules this order specifies the definitions of the classes where licence exemptions apply:

- Schedule 2 Exemptions From Section 4(1)(A) Of The Act (Generation Exemptions)
- Schedule 3 Exemptions From Section 4(1)(Bb) Of The Act (Distribution Exemptions)
- Schedule 4 Exemptions From Section 4(1)(C) Of The Act (Supply Exemptions)

The Electricity Safety, Quality and Continuity Regulations (ESQCR) 2002

These regulations specify the fundamental obligations for safety, quality and continuity of supplies, under the following headings:

- Part II Protection And Earthing
- Part III Substations
- Part IV Underground Cables And Equipment
- Part V Overhead Lines
- Part VI Generation
- Part VII Supplies To Installations And To Other Networks

The Electricity (Class Exemptions from the Requirement for a Licence) (Amendment) Order 2005

This order amends the 2001 order by:

- Substituting the provisions for ‘Class C: Generators not exceeding 100 megawatts’;
- Adding an additional class: ‘Class D: Generators never subject to central despatch’.

The Electricity and Gas Appeals (Designation and Exclusion) Order 2009

Designation of documents

3. For the purposes of section 173 of the Act, the following documents are designated—

(a) the Distribution Connection and Use of System Agreement;…

The Electricity and Gas Appeals (Designation and Exclusion) Order 2009

The Electricity (Applications for Licences, Modifications of an Area and Extensions and Restrictions of Licences) Regulations 2010

From the explanatory note provided with the regulations: ‘these Regulations set out the information and other documents that are required to be submitted with applications for generation, transmission, distribution, supply and interconnector licences…’. The details are provided in the form of an application form and summary guidance in the schedule to the regulations.

The Electricity and Gas (Internal Markets) Regulations 2011

These regulations provide a further amendment to the Electricity Act 1989 (section 6, paragraph 2) which was previously amended by the Utilities Act 2000 (section 30):

(2) The same person may not be the holder of both a distribution licence and

(a) a generation licence; or

(b) a supply licence

The Electricity and Gas (Internal Markets) Regulations 2011, section 19

The Electricity and Gas Appeals (Designation and Exclusion) Order 2014

This order

‘Designation of documents

3. The following documents are designated for the purposes of section 173 of the Act—

(a) the Balancing and Settlement Code, being the document of that title required to be prepared pursuant to Standard Condition C3 of a transmission licence;

(b) the Connection and Use of System Code, being the document of that title required to be prepared pursuant to Standard Condition C10 of a transmission licence;

…

(g) the Master Registration Agreement, being the document of that title required to be entered into pursuant to Standard Condition 11 of an electricity supply licence;

(h) the Distribution Connection and Use of System Agreement, being the document of that title referred to in Standard Condition 22 of a distribution licence;

…

The Electricity and Gas Appeals (Designation and Exclusion) Order 2014

3.3 Discussion of barriers and potential solutions

3.3.1 Limitations in legal definitions and explicit provision for network islanding

The primary barrier that potentially results from the existing legal framework is limitations in the formal definition and/or explicit treatment of technological and other recent developments in the sector. These include:

- Network islands or microgrids with intentional islanding mode;
- Energy storage, which is considered to be a subset of generation, but has significantly different operating characteristics;
- Distribution System Operator (DSO), which is a term that is being used more and more frequently, but is to mean different things;

Network islands or microgrids

Regarding the legal and regulatory environment in GB, a major barrier for widespread application of network islands is the lack of suitable standards and regulations for the legal interpretation of network islands. These are required to define the responsibilities, requirements, boundaries, and rules about financial transactions. Many questions arise concerning financial liabilities. For example, an important concept for regulation is whether network islands can be considered as both a consumer of power (in grid-connected mode) and a producer (when exporting to the grid during periods of excess generation) [18]. The lack of suitable standardisation also introduces a high risk of potential hazard in operation of the network and generation

Multiple definitions of network islands and microgrids exist in various items of scientific literature, but there is variation between them relating to the duration of islanded mode operation and available technologies. However, there is not yet a fully developed legal definition, which could jeopardise the successful implementation of network islands. In many cases, definitions of network islands and microgrids are comparable with definitions of smart grids [19]. To date policies, regulations and rules relevant to the distribution network vary significantly by region as well as individual nations.

For instance, the U.S. has developed IEEE standards 1547 for DG interconnection and usage since 2004. Following that example, the State of California in the U.S. became one of the leaders in microgrid development by introducing the SB 1339 policy for creating tariffs, operational rules and time frames. As a result of that new addition to Californian legislation, the barriers to future microgrid projects are likely to be reduced [20].

The IEEE 1547.4-2011 standard called “Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems” is treated as a fundamental technical document for the standardisation of islanded networks and operation in the United States. Many countries around the globe have already implemented a regulatory framework to enable widespread deployment of microgrids. Intensive research and discussions are going on in the United States.

According to the 'International Microgrid Assessment: Governance, INcentives, and Experience (IMAGINE)' paper in the ECEEE 2013 Summer Study Proceedings [21], the European Union (EU) was 'the earliest leader in microgrid development, with comprehensive R&D efforts dating back to 1998. Under the 5th, 6th and 7th Framework Programs (FP), comprehensive research and demonstrations have been carried out in the area of microgrids'. It is understood that this is driven by the Electricity Directive, which requires intensive roll out of smart meters as a first step in the microgrid/network islands regulations.

Through the duration of these programmes many microgrid demonstration projects were deployed, for instance, the Kythnos Island Microgrid and the Bornholm Island Multi Microgrid. However, there is still no specific directive for the implementation of network islands or microgrids in the EU, in spite of evidence to suggest that environmental targets could be addressed by effective deployment of network islanding technologies [18]. Another example of effective legislation can be seen in Sweden with the regulation of locally shared heat in the form of a District Heating Act.

Importantly, Singapore is an ideal example of microgrid deployment from a regulatory point of view. Firstly, in Singapore microgrids are not mentioned in the regulations. However, as the Singaporean energy market is well regulated and transparent, it makes it attractive and accessible for business and investment. Secondly, Singapore defined microgrids as vital elements in its energy strategy, and the international cooperation is a key part of its energy policy framework to encourage technical development.

The legality and definition of microgrids are linked to the treatment of embedded generation in the view of Singaporean regulation. Under definitions in the District Cooling Act, the "small or building microgrids are the most likely to be treated as a combination of both a utility energy service and generation capacity, which is allowed to export electricity without registering with the Energy Market Authority" [19]. This mechanism aims to support the market to allow DG to access it freely.

It may be more appropriate to make changes to the Distribution Code and Engineering Recommendations (which work with legislation) for islanded mode of operation, to allow network islands to operate under certain conditions. Sub-sections 4.2.2 and 4.3.3 provide an overview of this issue.

Energy storage

There are similar issues for energy storage facilities which have been developed to a limited extent due to the outdated licensing regime. The Electricity Act 1989 does not explicitly define an energy storage licence or obligations. Therefore, the owners batteries have a requirement to apply for generation licences or exemptions in order to legally operate their assets within the distribution network [22]. According to ongoing Ofgem consultations [23], modifications to the generation licence conditions to account for energy storage are being considered.

DSO

There are a large number of literature sources that refer to the role of a DSO as being necessary for the future development of a sustainable network. Work is ongoing under the Open Networks Project [24], however, legal requirements and boundaries of responsibilities and duties have not been fully developed. Many writers make assumptions about the likely role of the DSO, and what is required of this role to enable many other developments in the sector to be deployed. However, this adds significant uncertainty.

The work on the 'Upgrading our Energy System – Smart Systems and Flexibility Plan' mentioned in sub-section 4.2.5 may result in proposed changes to legislation as well as regulatory documents [25] in relation to the role of the DSO.

3.3.2 Potential incompatibility of network islanding with meeting statutory duties

A number of areas have been identified where compliance with current explicit statutory duties may be compromised by network islanding. It should be noted that these areas of concern cannot be considered in isolation. They are intimately linked with the technological developments that naturally occur faster than changes in legislation. In all likelihood, with a degree of effort technical solutions, such as those identified in the high level review report, will enable statutory duties to be met in the future. However, consideration should given to the following identified areas where network islanding may have a detrimental effect on:

- Safety;
- Competition in generation and supply; and
- Cost recovery.

3.4 Summary

Approaches / Considerations	Islanding to enable greater use of renewable energy resources	Islanding to increase security of supply	Islanding as an alternative to traditional network reinforcement	Islanding to reduce other costs	Islanding as a tool for operating network with greater flexibility and resilience
Requirements	The legal framework underpins all of the activities in the sector, and comprises a complex array of documents including primary and secondary legislation. The nature of legislation is generally quite broad, determining: the structural organisation of the sector to provide accountability and the regulatory framework to protect the interests of customers; and fundamental requirements about the standards of service to customers and to protect safety. Modification of legislation naturally lags behind technological developments, and the immediate requirements imposed by legislation should be considered to be non-negotiable.				
Barriers	The potential barriers to network islanding resulting from the current legal framework are as follows: • Limitations in the legal definitions and explicit provision for network islanding, energy storage and DSO; • Potential incompatibility of network islanding with meeting statutory duties.				
Possible solution	The possible solution to overcome the barriers to network islanding is to engage with ongoing activities led by Ofgem (consultations), and work under the Smarter Systems and Flexibility Plan, including the Open Networks Project. In summary, possible solutions have been identified that look to have potential to mitigate the barriers sufficiently such that network islanding remains feasible within the legal framework.				

4. Research of regulatory considerations of network islanding

4.1 Introduction

The following section reviews the regulatory requirements that are in place on networks across Great Britain. These include the requirements of the various sector licences, industry codes, frameworks and methodologies. Although operating islanded networks is already considered in some of the existing codes, it is generally expected that it would be for emergency purposes only. Therefore, the review has investigated the impact that regulation could have on more permanent network islands and summarises the potential solutions that are available.

4.2 Concepts and requirements

4.2.1 Electricity licences

Ofgem maintains Standard Licence Conditions (SLCs) for five licensable activities in the electricity sector, as follows, as well as those for gas sector activities:

- Electricity Distribution;
- Electricity Generation;
- Electricity Interconnector;
- Electricity Supply;
- Electricity Transmission.

Amended Standard Licence Conditions and Special Conditions are also agreed and applied to licensees. The Electronic Public Register (EPR) maintained by Ofgem [26] documents the current and previous Licence Conditions, Determinations, Metering Documents, Industry Codes Documents and Exemptions for all of the Licensees.

WPD is subject to the Electricity Distribution Standard Licence Conditions (SLCs) for its four licence areas (South West, South Wales, East Midlands and West Midlands [1]). In addition to the SLCs, the EPR shows in the region of 410 files relating to WPD (likely to include some superseded versions of documents). It should be noted that the research exercise presented in this report did not extend to review of all of the files identified in the EPR. This is high level research with a focus on the documents that are most pertinent to the issues that are likely to arise from intentional network islanding, in view of the time and resources available.

During the course of this high level research, the current available version of the consolidated SLCs for Electricity Distribution have been considered [27]. These are dated 25 August 2017, although it was confirmed by Ofgem that these are due to be updated shortly. By way of summary, the SLCs include the following chapters with relevant material highlighted and explained below:

- Section A: Standard Conditions for all Electricity Distributors:
  - Chapter 1: Interpretation and application;
  - Chapter 2: General obligations and arrangements;

[1] Formerly the East Midlands and West Midlands networks formed the midlands network operated by Powergen and Central Networks.

– Chapter 3: Public service requirements;
– Chapter 4: Arrangements for the provision of services

In this chapter Condition 12 imposes requirements on licensees regarding provision of agreements for use of their system and treatment of requests to connect. In broad terms, licensees must respond to connection requests and offer to enter into use of system agreements with those who request them (both generators and demand customers).

Conditions 13, 13A and 14 impose requirements on licensees to 'at all times have in force' charging methodologies for use of system and connection, and corresponding published charging statements.

Condition 15 imposes requirements on licensees for responding to requests for 'non-contestable connection services', i.e. the works that are required to be undertaken by the licensee even when other aspects are undertaken by a third party (competition in connections).

– Chapter 5: Industry codes and agreements;

Condition 20 imposes requirements on licensees to comply with Core Industry Documents, 'so far as they are applicable to the licensee'. The principal requirements are to: 'comply with the Grid Code'; 'have in force, implement, and comply with the Distribution Code'; and 'be a party to and comply with: (a) the Balancing and Settlement Code; (b) the Connection and Use of System Code; (c) the Distribution Connection and Use of System Agreement…'.

Condition 21 presents the licensee's obligations relating to the Distribution Code which, firstly, 'must cover all material technical aspects relating to connections to and the operation and use of the licensee's Distribution System or… plant connected to that system'. This condition states that 'the Distribution Code must include a Distribution Planning and Connection Code and a Distribution Operating Code', and make provision for a panel body and nominated code administrator whose functions include to 'facilitate the procedures for making a modification to the Distribution Code'. Modifications are considered through periodic reviews (in consultation between affected parties, and proposed modifications are subject to approval by the Authority.

Condition 22 establishes obligations to ensure the DCUSA in force meets stated objectives. It requires that proposals (from different parties) for modification of the DCUSA may be considered in line with stated principles, but they are subject to approval by the Authority.

Condition 22A requires that any changes to charging methodologies are 'to be made in each case by reference to the Applicable Standard conditions of the Charging Methodology Objectives specified in Part B of this condition 22A, rather than the Applicable DCUSA Objectives specified in standard condition 22 that would otherwise apply.'

– Chapter 6: Integrity and development of the network;

Condition 24 imposes requirements on licensees 'plan and develop its Distribution System in accordance with:

(a) a standard not less than that set out in Engineering Recommendation P.2/6 of the Energy Networks Association so far as that standard is applicable to it; or

(b) such other standard of planning as the licensee, with the Authority's approval, may from time to time adopt after consulting (where appropriate) with the GB System Operator and any other Authorised Electricity Operator likely to be materially affected.'

Additionally, this condition requires licensees to draw up 'a statement that sets out criteria by which the licensee's quality of performance in maintaining the security, availability, and quality of service of its Distribution System may be measured.' They must then submit an annual report of performance against these criteria.

Condition 25 relates to preparation and maintenance of a Long-Term Development Statement document, that the Authority directs licensees to undertake. This is 'for the purpose that the licensee: (a) provides information that will assist any person who might wish to enter into arrangements with the licensee that relate to Use of System or connections to identify and evaluate the opportunities for doing so; and (b) makes such information generally available in the public domain.'

Condition 25A imposes requirements for licensees to work together to 'prepare and maintain a common set of documents, approved by the Authority and to be known as the DG Connections Guide…'.

  - Chapter 7: Financial and ring-fencing arrangements;
- Section B: Additional Standard Conditions for Electricity Distributors who are Distribution Services Providers:
  - Chapter 8: Application and interpretation of Section B;
  - Chapter 9: Requirements within the Distribution Services Area;

Conditions 34 to 39 impose obligations on licensees to: provide legacy metering equipment where required by a customer; offer to enter into an agreement to provide data services; establish, operate and maintain the Data Transfer Service; and pay claimants who submit valid claims for last-resort supply (and adjust use of system charges to recover associated costs).

  - Chapter 10: Credit rating and Restriction of Indebtedness;
  - Chapter 11: Independence of the Distribution Business;
  - Chapter 12: Provision of regulatory information.

4.2.2 Industry codes and subsidiary documents

The principal industry codes identified that are relevant to intentional islanding of networks are the:

- Distribution Code – administered by the ENA [28];
- Distribution Connection and Use of System Agreement – administered by Electralink [29];
- Grid Code – administered by National Grid [30];
- Connection and Use of System Code – administered by National Grid [31]; and
- Balancing and Settlement Code – administered by Elexon [32].

Distribution Code

The Distribution Code is made up of the following documents:

- Distribution Code Introduction (DIN) – 'Introduces the Distribution Code' [33];
- Distribution Glossary and Definitions (DGD) – 'Defines terms used in the Distribution Code';
- Distribution General Conditions (DGC) – 'Contains conditions that apply to all aspects of the Distribution Code';

- Distribution Planning and Connection Code (DPC) – 'Specifies technical, design and operational criteria and procedures';

This document includes the section 'DPC4.2 Standard of Supply' which references Engineering Recommendation P2/6 – "Security of Supply" as the required standard for security in section DPC4.2.1.

Section 'DPC4.2.2 Frequency and Voltage' restates the requirements of the ESQCR for normal operation. It adds the following:

'DPC4.2.2.3 In exceptional circumstances, System Frequency could rise to values of the order of 52 Hz or fall to values of the order of 47 Hz. Sustained operation outwith the range 47 - 52 Hz is not taken into account in the design of Plant and Apparatus.'

Subsequent sections in this document provide further technical requirements and design principles (relevant to both DNO and customer installations), including sections:

- DPC4.2.3 Voltage Disturbances and Harmonic Distortion;
- DPC4.4.1 Specification of Equipment, Overhead Lines and Underground Cables;
- DPC4.4.2 Earthing
- DPC4.4.3 Voltage Regulation and Control
- DPC4.4.4 Protection

Distribution Code (Distribution Planning and Connection Code)

- Distribution Operating Code (DOC) – 'Sets out operating procedures and information required';
- Distribution Data Registration Code (DDRC) – 'Provides guidelines for the collection of information exchanged between Users and DNOs';
- Annex 1 – 'Lists the Electricity Industry Standards in which Distribution Code requirements are implemented';

The standards considered to be of most relevance to network islanding are listed below:

'1 Engineering Recommendation G5/4-1

Planning levels for harmonic voltage distortion and the connection of non-linear equipment to transmission and distribution systems in the United Kingdom.

2 Engineering Recommendation G12/4-1

Requirements for the application of protective multiple earthing to low voltage networks.

3 Engineering Recommendation G59/3-4

Recommendation for the connection of generating plant to the distribution systems of licensed distribution network operators

4 (a) Engineering Recommendation P2/6

Security of Supply…'.

Distribution Code (Annex 1)

- Annex 2 – 'Lists the Standards that are not implemented via the Distribution Code but have an impact'.

The standards considered to be of most relevance to network islanding are listed below:

'…2 Distributed Generation Connection Guides (published by Energy Networks Association)

3 Engineering Technical Report 130-1

Application Guide for assessing the Capacity of Networks Containing Distributed Generation

4 Engineering Technical Report 131

Analysis Package for Assessing Generation Security Capability – Users' Guide…'.

Distribution Code (Annex 2)

The Distributed Generation Connection Guide [34] provides a good overview of the context and regulatory framework for connecting DG in the UK, the connection application process, costs, charges and potential tariffs for the sale of electricity (with reference to the feed-in tariffs that can be applied for following installation of certain generators up to 5MW in capacity, subject to deployment caps).

Distribution Connection and Use of System Agreement (DCUSA)

The DCUSA was established in October 2006 to replace numerous bi-lateral contracts. It was developed as a common 'multi-party contract between the licensed electricity distributors, suppliers and generators of Great Britain' to set a template for the nature of the relationships between them [35].

The DCUSA is made up of the following sections:

- Section 1 - Governance and Change Control
  - Section 1A – Preliminary
  - Section 1B – Governance
  - Section 1C – Change Control
- Section 2 – Commercial Arrangements
  - Section 2A - Distributor to Supplier/Generator Relationships

In chapter 17 'Contracts', there is a provision that means that the distributor appoints the supplier/generator as its agent '…for the purpose of procuring agreements with Customers and Generators on the terms set out at Schedule 2B (the National Terms of Connection)…'. This means that domestic customers do not have much significant contact with DNOs, since the contracts that are established with DNOs are administrated by the suppliers acting as agents for the DNOs (whilst establishing their own contracts with the customers).

Chapter 18 'Use of System' covers the necessary contractual arrangements between the parties regarding use of the system, which principally comprises of prior requirements that include the requirement for a Connection Agreement.

Chapter 19 'Charing' covers the contractual arrangements relating to charging for the services provided. Clause 19.1 states that:

'The User shall pay to the Company in respect of services provided under this Agreement (and under the agreements referred to in Clause 19.2) the Charges set out in the Relevant Charging Statement (save where the Company is the Payor, in which case the Company shall pay such charges to the User)'.

The document refers to the relevant charging statement as that 'prepared by a Company in relation to charges for use of system for the time being in force pursuant to Condition 14 of its Distribution Licence'. The distribution licence conditions require that charging statements are prepared and are consistent with the charging methodologies. These generally have to include the Common Connection Charging Methodology (CCCM) and the Common Distribution Charging Methodology (CDCM) which are included as schedules within the DCUSA.

Chapter 25 deals with contractual arrangements for 'Energisation, De-Energisation and Re-Energisation' that may be required during the course of works undertaken by the user or the DNO on behalf of the user.

Chapters 29, 30 and 31 deal with contractual arrangements for 'Metering Equipment and Metering Data', 'Provision of Information' and 'Demand Control'.

DCUSA (Section 2A)

- Section 2B - Distributor to Distributor/OTSO Relationships
- Section 2C - Distributor to Gas Supplier Relationships
- Section 2D - Electricity Supplier to Gas Supplier Relationships
- Section 2E - Distributor to Third Party Electricity Supplier Relationships
- Section 2F - Electricity Supplier to Third Party Electricity Supplier Relationships

- Section 3 - General Provisions
- Various schedules, including:
  - Schedule 2A – Mandatory Terms For Contracts
  - Schedule 2B – National Terms Of Connection Schedule 13 – Bilateral Connection Agreement
  - Schedule 16 – Common Distribution Charging Methodology

The principles of the use of system charging methodologies adopted, based on the Common Distribution Charging Methodology (CDCM), are summarised in sub-section 4.2.4.

  - Schedule 17 – EHV Charging Methodology (FCP Model)
  - Schedule 18 – EHV Charging Methodology (LRIC Model)
  - Schedule 22 – Common Connection Charging Methodology

The principles of the connection charging methodologies adopted, based on the Common Connection Charging Methodology (CCCM), are summarised in sub-section 4.2.4.

  - Schedule 28 – Distribution Charging Methodologies Development Group
  - Schedule 29 - Calculation Of Discount Percentages For The Purpose Of Determining Certain LDNO Use Of System Charges Under Schedules 16,17 and 18

Grid Code

The Grid Code 'sets out the operating procedures and principles governing the relationship between The Company [National Grid (the Electricity System Operator)] and all Users of the National Electricity Transmission System, be they Generators, DC Converter owners, Suppliers or Non-Embedded Customers. The Grid Code specifies day-to-day procedures for both planning and operational purposes and covers both normal and exceptional circumstances' [30].

Whilst the Grid Code principally deals with technical issues relating to the operation of the transmission system, DNOs are required to comply with its provisions under their licences.

'DIN2.3 It is also a requirement of the Distribution Licence that the DNO shall comply with the provisions of the Grid Code so far as applicable to the licensed business, and the Distribution Code is designed to ensure that these obligations can be met by the DNO'.

Distribution Code (Distribution Introduction)

In addition, the Grid Code is relevant to the consideration of network islanding since it affects embedded generators and suppliers who also have obligations under the Grid Code. The Grid Code is part of the regulatory framework for embedded generators since, whilst they are directly connected to distribution networks, they are deemed to derive benefit from the ability to export power through interconnections with the transmission network.

Connection and Use of System Code (CUSC)

Similarly, the CUSC is relevant to embedded generators that benefit from interconnections to the transmission network via the distribution networks to which they are directly connected. In section 1.3.1, the CUSC mandates the need for generators to have Bilateral Connection Agreements (BCA) or, in the case of small and medium embedded generators, Bilateral Embedded Generation Agreements (BEGA). The terms of the BEGA are provided in schedule 2, exhibit 2 of the CUSC.

Balancing and settlement code (BSC)

The BSC was 'introduced as part of the New Electricity Trading Arrangements (NETA)' in March 2001, and 'subsequently extended to Scotland in April 2005 as the British Electricity Trading and Transmission Arrangements (BETTA)' [36]. This followed the creation of Ofgem under the Utilities Act 2000, 'Ofgem and the Department of Trade and Industry shared responsibility for the implementation of NETA' [37].

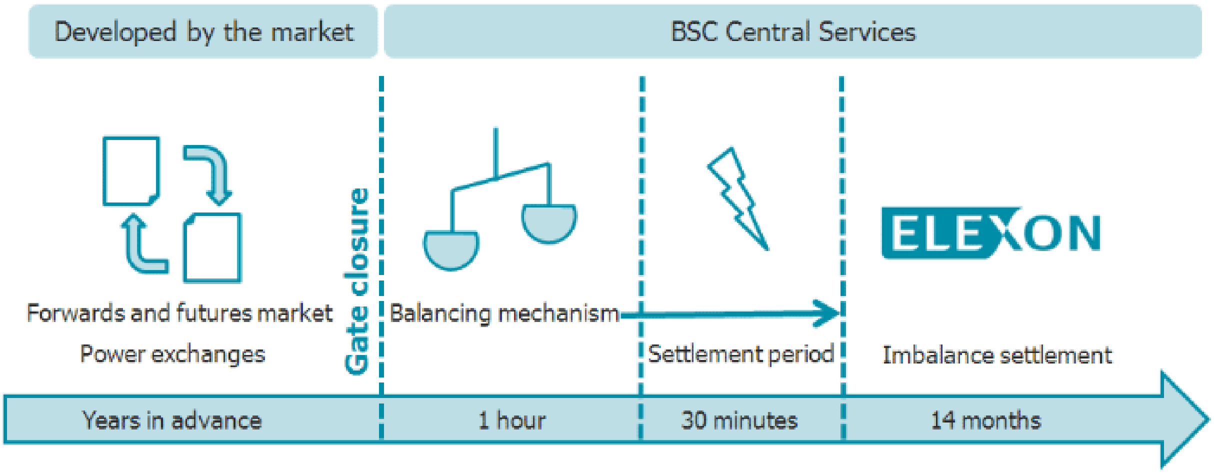
The BSC 'contains the governance arrangements for electricity balancing and settlement in GB' [38]. It supports the electricity trading arrangements, i.e. the operation of the wholesale electricity market, balancing mechanism used by National Grid to balance supply and demand in real-time and associated financial settlements for imbalances.

Elexon acts as the Balancing and Settlement Code Company (BSCCo). In its guidance about the BSC trading arrangements it states that: 'It is a condition of a Generation and Supply Licence that licensees… must become BSC Parties… Other parties who are not licensees have the option to sign the BSC Framework Agreement, which provides them the right to notify energy contract volumes and register BM Units (if they are Interconnector Users or licence exempt). This exposes them to any charges and payments that result' [39].

The BSC is, therefore, relevant to network islanding because, although they do not have significant responsibilities under the BSC ('essentially for the provision of certain metered data' [39]), if DNOs implement network islands then this affects the bilateral contracts, obligations and interaction with the settlement mechanism of the embedded generators within the islands.

By way of summary, the guidance also states that in the wholesale electricity market in GB, 'most of… [the] trading is done in a forwards market, with generators and suppliers entering into contracts with each other for every half hour of every day; sometimes years in advance… For each half hour, they can continue to trade up to 1 hour beforehand, at which point the market for that time period is closed. All generators and suppliers have to notify National Grid of their planned supply and demand for each half hour of the day.' [40].

This wholesale market replaced the earlier pool arrangement, which consisted of a central buyer and seller, 'to balance the supply and demand for electricity through market mechanisms' [41]. Following the closure of the wholesale market an hour in advance of real-time, the balancing mechanism is employed to achieve balance of the system, as shown in Figure 4-1.



Source: reference [42].

Figure 4-1 Trading and settlement timescales

The BSC is a large document underpinning a complex set of arrangements implemented by Elexon. Figure 5-1, in sub-section 5.2.2, presents the organisation of agents and their interactions which correspond to the systems implemented under the BSC.

The principal sections of the BSC that define aspects of the arrangements that are relevant to network islanding are summarised as follows:

- Section E – this section makes provision for various agents who '…are not Parties to the BSC but are appointed, either by ELEXON or by BSC Parties, to fulfil certain functions. Agents to the BSC include the Settlement Administration Agent (SAA), Central Data Collection Agent (CDCA), Energy Contract Volume Aggregation Agent (ECVAA) and the Funds Administration Agent (FAA), and these functions are performed under contract to ELEXON' [39].
- Section J – this section makes provision for party agents that 'include the Energy Contract Volume Notification Agents (ECVNAs) and Meter Volume Reallocation Notification Agents (MVRNAs) that notify bilaterally contracted volumes on behalf of Parties' [39].
- Section K – this section 'deals with the classification and registration of Metering Systems, BM Units and Trading Units' [39] such that responsibilities can be allocated according to defined terms. It establishes the criteria for registration of metering system to Central Volume Allocation (CVA) and/or Supplier Volume Allocation (SVA) [43];
- Section L – this section states the requirements for metering equipment to measure active and reactive energy;
- Section P 'Energy Contract Volumes and Metered Volume Reallocations' – this section deals with the notification of 'contract volumes to settlements' [44]
- Section Q 'Balancing Services Activities' – this section deals with information flows to/from balancing mechanism (BM) units, to enable bid-offer pairs for each BM unit to be evaluated by the National Electricity Transmission System Operator (NETSO) and accepted according to set rules [45] Section R 'Collection and Aggregation of Meter Data from CVA Metering Systems' – this section details the rules for the determination of metered volumes data for CVA metering systems;
- Section S 'Supplier Volume Allocation' – this section, and associated annexes, sets out 'the rules by which the rules by which Supplier BM Unit Metered Volumes are determined from a combination of Half Hourly and Non Half Hourly Metering Systems' [46];

- Section T – Settlement and Trading Charges – this section sets out ‘the majority of the algebraic calculations’ [47] to determine the applicable charges for each party on each settlement day;

4.2.3 Evolution of the regulatory framework

Regulatory development has been the primary motivation in shaping the modern electricity industry in GB. Likewise, the behaviour of industry participants has driven changes to the regulatory framework. Ofgem, as the regulator of Electricity and Gas industries, sets price control for the companies that own and operate Britain's electricity and gas networks.

RPI-X

Price control or price-cap is a form of regulation, which was designed in 1989 in the U.K. In short, it takes Retail Price Index (a measure of inflation from previous years) and applies an expected efficiency improvement (-X) during the time period the price adjustment formula is in place [48]. The value X is based on the general performance of the whole industry. RPI-X is, consequently, intended as a proxy for a competitive market is a set of industries that are a natural monopoly. The period of RPI-X price control was reviewed for five years. Ofgem has been developing a framework to update the RPI - X formula and incentive regulation, which is at the centre of all monopoly price controls [49].

Due to the increasing need for investments in operating network safely and replacing ageing infrastructure, the regulator developed and announced a renewal of RPI-X framework with Sustainable Network Regulation – based on the RIIO financial model.

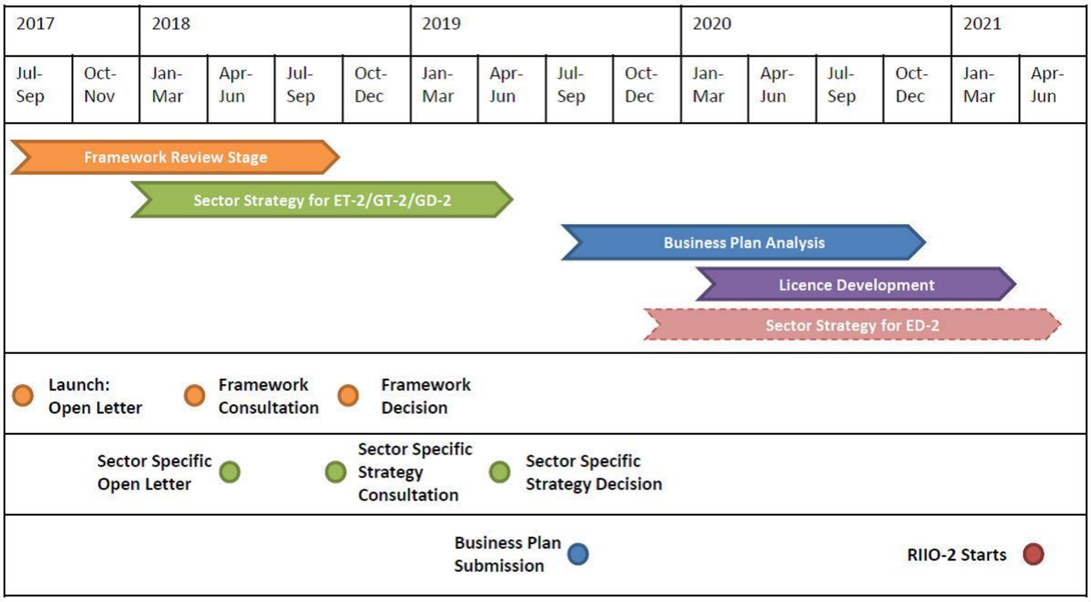
RIIO

RIIO became Ofgem’s new framework for setting price control, which regulates the allowed revenue that can be earned by the network operator during the length of time. The framework comprises elements of:

- An upfront eight-year price control plan that defines network operator aims and allowed revenues for achieving them.
- Put stakeholders in the centre of the decision-making process and give them a more significant role in the delivery of project
- Encourage innovation to reduce network costs as well as play a full part in developing a low carbon future.

RIIO stands for “Revenue using Incentives to deliver Innovation and Outputs”, which can be shortened to ‘Revenue = Incentives + Innovation + Outputs’. The programme comes in three types: T1 for governing electricity and gas transmission, ED1 for electricity distribution and GD1 for gas distribution companies. RPI-X was replaced for electricity and gas transmission and gas distribution in April 2013, and in April 2015 RIIO took over electricity distribution covering period till March 2023. According to CEPA review of RIIO-1 performance [50], “RIIO-1 has succeeded at incentivising network companies to better deliver outputs for customers”.

However, RIIO-1 was the first application of the RIIO price control framework. By given complexity of the regulation and expended length of framework, some issues are room for improvement was identified and addressed in RIIO-2 framework [50].



Source: reference [51]

Figure 4-2 Framework development of RIIO-2

RIIO-2 is the next price control for the transmission companies and gas distribution from 2021 and electricity distribution companies from 2023. The objectives highlight the value of delivery services for both existing and future customers and, in particular, pay attention to reducing the impact of networks on the environment. Some of the many changes in the framework involve the decision to [52]:

- Give the customer a stronger voice and introduce open public hearing to focus on disagreements and issues.
- Shorten the length of price control to five years.
- Set a separate electricity system operator (ESO) price control scheme.
- Retain and support an innovation stimulation package.
- Simplifying the price controls by focusing on items of highest value to consumers.

It is crucial to notice that RIIO-2 is committed to improving the quality and transparency of financial reporting by network companies and addressed customer vulnerability issues.

4.2.4 Charging methodologies

The common charging methodologies that are included as schedules to the DCUSA, identified in section 4.2.2, are designed to recover the costs associated with ongoing use of the system and connection to the system in different ways. The use of system charge is designed to recover the shared cost of having an operational network by applying an average charge to all customers. The connection charge methodology is designed to recover all of the direct costs associated with providing a new connection to the network from the individual that requests the connection. However, a consistent methodology is adopted to determine the portion of the cost of associated network reinforcements (that are instigated by the connection request) that is recovered as a shared cost through the use of system charge.

'The boundary between the on-going costs [including for maintaining, repairing and replacing network assets] in the allowed revenue [set by Ofgem in each DNO's price control determination] and those directly paid for [by customers] is called the Connection and Use of

System Boundary. This boundary is currently set at what is termed a “shallowish” boundary and it is the same for both demand and generation users. The “shallowish” boundary essentially means that new connections are required to pay for the assets required to connect them to the network and, where required [to a limited extent], to contribute towards the reinforcement of the existing network’.

ENA - Distribution Charges Overview [53]

Use of system charging methodology

The CDCM applies to the majority of customers connected at voltages below 22kV. It ‘gives the methods, principles, and assumptions underpinning the calculation of Use of System Charges by each DNO Party…’ [29].

The CDCM is a ‘common charging methodology’ (with accompanying calculation model) that is used across GB by all DNOs. The methodology was ‘developed through joint collaboration between DNOs, Ofgem and interested stakeholders. The CDCM was implemented in April 2010 for both demand and generation users connected at LV and HV’.

The DUoS tariffs calculated through the CDCM model ‘are then charged to suppliers and the charges collected during the year. The charges collected will not exactly match the Allowed Revenue due to the difference between estimated consumption and actual consumption, and other factors. The difference, over/under recovery, then becomes a factor in the following year’s revenue calculation.’

ENA - Distribution Charges Overview [53]

The CDCM comprises of two main parts:

- 'Part 1 describes the cost allocation rules’ which, for licensed DNO (LDNO) tariffs, consist of matching the revenues allowed under the price control with the volume forecasts and the common tariff components; and
- ‘Part 2 describes the tariff structures and their application', providing ‘common tariff structure and associated tariff elements for Non-Half Hourly (NHH), Half-Hourly (HH) site-specific and HH aggregated metered supplies for demand and generation, for unmetered supplies and for charges to LDNOs’.

The common principles adopted in the CDCM provide a methodology for determining values for each tariff element that are judged to be a fair allocation that ensures allowed revenues are recovered. This has important consequences because the allocations between fixed and capacity charges (that do not vary with the amount of energy consumed) and the variable unit charges determine the overall approach to recovery of costs. To illustrate, two extreme approaches to the recovery of a fixed amount of allowed revenue are as follows, noting that a balanced approach is generally adopted:

- Setting the fixed and capacity charges to relatively low values would necessitate a relatively high unit charge to recover the fixed amount. This approach would result in high-volume demand or generation customers paying for a relatively higher proportion of the DNO revenue;
- Setting the fixed and capacity charges to relatively high values would necessitate a relatively low unit charge to recover the fixed amount. This approach would result in low-volume demand or generation customers, including fuel-poor households, paying for a relatively higher proportion of the DNO revenue.

Connection charging methodology

'Each DNO Party is obliged by Standard Licence Condition 13 to have a connection charging methodology in force… [and] to include the CCCM within its Connection Charging Methodology' [29]. As stated in the introduction to this section, the methodology reflects a "shallowish" approach to determination of connection charges. The methodology addresses the basis for calculation of charges, summarised as follows:

- The DNO must consider the 'minimum scheme', i.e. lowest cost available technical solution to provide the requested connection;
- The basis for the allocation of costs between parties, as follows:
  - Costs to be paid in full by the customer;
  - Costs to be apportioned between the customer and the DNO, with explanation of the application of equations for the security cost apportionment factor (CAF) and the fault level CAF (the latter is only generally applied for generation connection charges);
  - Recovery of costs for previous works that are used to provide the connection (under the 'second comer rules'); and
  - Costs to be paid in full by the DNO (that do not form part of the connection charge, and are thus recovered through the use of system charge).

4.2.5 Summary of regulatory implications for network islanding

As described above, there are a lot of developments occurring relating to the electricity sector regulatory framework. This reflects the fact that legislation provides for Ofgem, as the Regulatory Authority, to develop specific requirements to address the issues that arise in the sector. Ofgem generally undertakes this role through consultation with industry stakeholders on proposals that it makes. Many of the developments will directly impact the implementation of network islanding. Some comments are provided below about the relevance of key developments to network islanding.

The Upgrading our Energy System – Smart Systems and Flexibility Plan [25] developed by Ofgem and BEIS is addressing challenges associated with energy system changes resulting from the transition to a low carbon economy. The document aims to present actions to deliver a sustainable, smart and flexible future by removing barriers to many smart technologies and flexible electricity markets. The key to overcoming these barriers is to establish transparent markets for flexibility that 'facilitate competition between new types of flexibility, such as energy storage and demand-side response services and other solution like interconnection, generation, energy efficiency or network infrastructure' [25].

Indications suggest that network islanding is consistent with the objectives stated within the plan, including as a potential solution to address the lack of established markets in local flexibility services to manage local network constraints. Islanding necessitates DG to be available, and it is anticipated that energy storage solutions would be an attractive addition to obtain greater benefits. However, another issue considered in the plan is an action towards reducing regulatory barriers to development of energy storage facilities [25]. Ofgem launched two consultations in October 2017:

- 'Clarifying the regulatory framework for electricity storage: Licensing' [54] – consulting on changes to the electricity generation licence; and

- ‘Enabling the competitive deployment of storage in a flexible energy system: Changes to to the electricity distribution licence’ [55].

A recent decision from Ofgem on the second of the above consultations has confirmed that:

‘…licensees must ensure there is separation of operation of generation assets from the licensee’s activities, even where such assets may be licence exempt. The new licence condition will extend these separation requirements to the operation of any unlicensed generation, including assets with capacity of less than 50MW which have previously been granted automatic exemptions as per government policy. This new licence condition ensures that the effectiveness of unbundling requirements is retained for assets below the 50MW threshold and any ownership of such generation by licensees has no potential to distort or foreclose flexibility markets.’

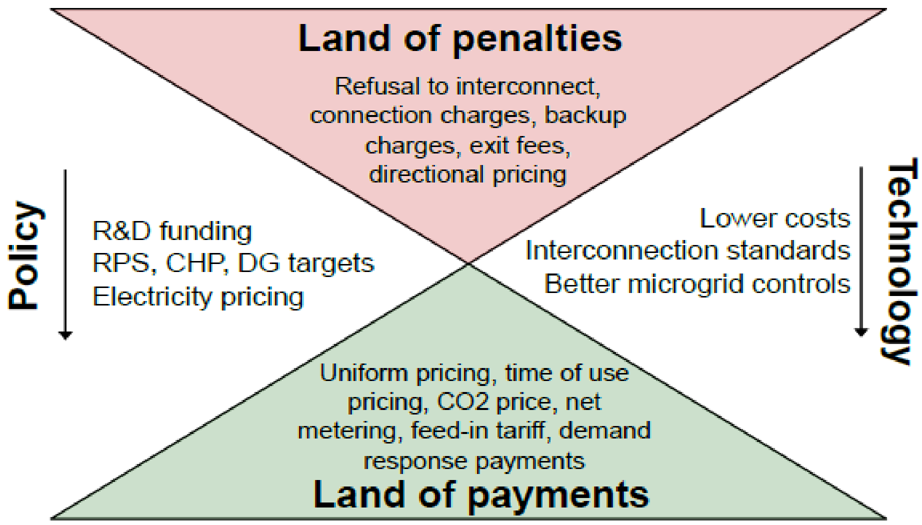
Decision on enabling the competitive deployment of storage in a flexible energy system: Changes to the electricity distribution licence [56]

In addition, there is ongoing work by Ofgem on the following:

- Targeted Charging Review: Significant Code Review:
  - Specific elements of the charging arrangements established in the CUSC and DCUSA, as described in section 4.2.4, are currently under review [57]. This review was launched by Ofgem in August 2017 with the aim to assess whether there is a need to reform residual network charges. It is considering whether “storage facilities should be paying the residual demand element of network charges at transmission and distribution level” [25]. A decision is awaited about a consultation on a minded-to decision regarding residual charging arrangements and ‘embedded benefits’ [58];
- Electricity Settlement Reform Significant Code Review
  - In 2017 Ofgem released a statement concerning mandatory half-hourly settlement (HHS) for domestic and smaller non-domestic customers [59]. It was predicted that implementing HHS for smaller customers would provide several benefits based on the smart metering schemes roll out and including more accurate and effective settlement process and tariff innovation. The regulator is likely to publish a decision on whether HHS should be mandatory for domestic customers later in 2019 and the outcome of this decision could affect regulatory aspects of network islanding [60]. In addition, Ofgem indicate that work is ongoing with Elexon to establish operating models to support market-wide half-hourly settlement.
- Specific issues relating to potential modifications to the BSC are discussed in the sub-section 5.2.2. Regulatory impacts of the resolution of barriers to network islanding arising from the arrangements implemented under the BSC will be subject to further research in the detailed research and analysis phase of the project.

Outcomes of the ongoing work by Ofgem should be considered carefully with respect to any impact on implementation of network islanding.

Taken from an international assessment [21], Figure 4-3 conveys that to derive the greatest benefit from developments in technologies and to meet increasingly demanding policy objectives necessitates that regulatory approaches move towards incentivising rather than penalising parties. The work that is ongoing in the UK to develop a regulatory framework that provides a smart and flexible system looks to be following this trend, and should strengthen market incentives for innovations like network islanding [25].



Source: reference [21]

Figure 4-3 Illustration of evolution of regulatory approaches

4.3 Discussion about barriers and potential solutions

4.3.1 Rules relating to ownership and responsibilities

In the energy sector, the existing regulatory frameworks in most jurisdictions were designed for the purpose of centralised and countrywide systems [18].There is also a common general trend of increasing DER adoption which may reduce the revenues of incumbent generators, introduce greater competition in the market and provide environmental benefits.

The increased volume of DER lends itself to creation of islands. Microgrid projects with infrastructure developed privately suffer from a lack of clear and stable regulations and processes that adds uncertainty to the microgrid projects' economics, which are often already challenging due to high upfront costs and contextual revenue streams [18]. The lack of clear regulations also represents a barrier to consideration of intentional islanding of portions of existing distribution networks that is the focus of this investigation project, but if this barrier ca be overcome then this may represent a cost effective solution since it does have the same level of upfront investment costs.

The drivers for network islands will determine the appropriate ownership model in response to the corresponding legal implications. The main factor, which differentiates the ownership models may be based on the separation between DNO/DSO and third parties [19]. The view to maintain separation to limit network and utility monopolies has implications in terms of allocation of liabilities, tariffs and metering arrangements [19]. The more common issues for all network islanding approaches are safety, protection, other technical requirements and environmental considerations.

		Present/ Distribution network	Future/ Network islands
Network	Operation	DNO	DSO
	Ownership	DNO	DNO/DSO
Distributed Generators	Operation	Third Party	DSO
	Ownership	Third Party	Third Party
	Balancing	Passive	DSO

Figure 4-4 Network islanding ownership models

In third-party owned networks, generation, storage and grid assets can be owned by a private organisation, and an assigned operator controls balancing of energy supplies, export of excess generation and resynchronisation with the main grid. There is potential for energy service companies (ESCo) to own assets. Third party ownership leads to infrastructure problems for independent entities as the DNOs own and control existing distribution assets. They receive regulatory allowances that are calculated based on the value of assets owned, so it is not foreseeable that DNOs would be prepared to transfer assets to third parties. Thus, third party owned network islands/microgrids would comprise private distribution lines, but they are likely to face significant barriers in terms of obtaining a connection to the utility grid and potential investment in duplicate infrastructure. This solution may be attractive in the case of high electricity prices [19]. According to the EU proposal, regulations of private wire network are essential aspects of the effective development of Local Energy Communities [61]. Licensing requirements and customer right to change their supplier could be a significant barrier for the potential private network operator.

Likewise, DNO/DSO-owned microgrids are entirely operated by the operator, which controls interconnection between the grid and islanded mode. Usually, these network islands are probably to be created in problematic sections of network or located close to existing large DG.

The challenges to implementation of intentional islanding by GB DNOs include the following:

- DNOs are prohibited from owning and operating generation assets - according to [17], there is a clear need for separation between the networks operation and generation and storage assets. If a network operator would be participating in the competitive market as a generator, it might gain unfair advantages over other generators. Many European countries prohibit DNOs from owning and operating generation and storage facilities, in line with Article 26 of the Electricity Directive and Clean Energy for all Europeans legislative proposal [62].
- The active management of the balance of supply and demand in distribution networks does not fall under the responsibilities currently held by DNOs;
- Creation of network islands (and active management of supply and demand within them) is likely to have an impact on balancing and settlement mechanisms.

A potential solution to this issue emerges with the hybrid model of network island ownership. In this model, DNO or DSO owns and operate the grid, but the external company or a third party owns and dispatches the DG. The key benefits of this solution are the fact that network operator could overcome challenges from legislation, whilst it derives benefits in terms of grid operation, interconnection and disconnection. In addition, a cooperation of a network operator and private organisation might have an ability to mitigate financial barriers [19]. A DNO or DSO could be in control of operation, providing balancing services in the network, overseeing safety requirements and owning network assets. Many sources consider the role of a network island operator or manager, who could be responsible of safe network operation. Meanwhile, generation or storage facilities would be owned by a third party and be operated in line with requirements for control and management of the network.

It is foreseeable that work to define the role of DSOs would conclude that it includes the role of local balancing by actively controlling generation dispatch, i.e. control of third party assets. At present the role of DSO is not technically or legally defined, as indicated in sub-section 3.3.1. Therefore, the regulatory environment does not exist for necessary contractual agreements to be established to enable such foreseeable elements of the DSO role to be fulfilled. It is anticipated that existing DNOs would be cautious about taking on responsibility for assets owned and operated by third parties, and that decisions about the regulatory treatment of DSOs would need to consider this.

4.3.2 Interconnection rules

Currently, most of the developed countries are heavily involved in research and development of different network innovations including network islands or microgrids [63]. According to [63, 19] undefined interconnection standards are among the most critical barriers for microgrids. It usually includes the development of connection practices with the utility grid. Missing standardisation, regulatory processes and transparency of costs and requirements all together add uncertainty and risk to network island project deployment. Different microgrids have different capabilities, and the costs of connection provision may vary according to the wanted security of supply, the flexibility of microgrid operation and participation in wholesome markets. Liabilities and responsibilities in system failure situations are mainly an undefined issue outside the public utility rules. Several policies have been applied to attract connection of small DGs by providing financial support, for instance, Renewable Obligation exemption. Interconnection practices should aim to maintain that embedded generation system will not interrupt other users of the network during regular operation and safety will be ensured. A possible solution for unclear standardisation of network islands has been found in international standards, which are currently approved and proven to be effective overseas.

Early in 2003 in the U.S., the IEEE 1547 standards was published in order to set out the technical standards that could be utilised and applied on a national scale. These regulations have recognised the capability of islanding section of the network could improve power supply reliability. Also, the issue of unplanned islanding was noticed to provoke serious issue for safety in the network. It could be possible that GB technical standards might take an example from IEEE standard 1547-family for Interconnecting Distributed Resources with Electric Power System (EPS) devices, which define technical regulations for DG interconnection. IEEE 1547 addressed unintentional and intentional islanding concepts, including technical provision as stated below:

- Voltage and power quality standards;
- Protection systems and anti-islanding scheme;
- Earthing arrangements;
- Power factor [64].

During the development of these IEEE standards, it was released that the intentional islanding of the distribution network would be beneficial to distribution system operators and customers reliability. The relevant to microgrids or network islanding documents of IEEE 1547 consists of as follow [63]:

- 1547.1 (2005): The rules governing the connection of the DGs to the EPS.

- 1547.2 (2008): an Application Guide for IEEE standard 1547.
- 1547.3 (2007): Guide for monitoring and communication of DGs. It also facilitates interoperability of DGs in interconnected mode.
- 1547.4 (2011): Design operation and integration of distributed resource island systems. Part of 1547.4 standards is considered as one of the fundamental standards as it deals with vital planning and operation aspects of mGrid, such as impacts of voltage, frequency, power quality, protection schemes and modification.
- 1547.6 (2011): Guide of interconnection with Distribution Secondary Networks types of area EPS with DG.
- 1547.7 (2013): This guide is a very significant step to standardise and universalise mGrid and DG systems. It emphasises on the methodology, testing steps and aspects to assess the impact of a DG on the system.

4.3.3 Potential incompatibility of network islanding with requirements stated in engineering recommendations

Sections DPC7.4.3.2 and DPC7.4.7 of the Distribution Code appear to give contradicting statements about disconnection of embedded generators in the case where one or more phases is lost.

DPC7.4.3.2 Specific Protection Required for Embedded Power Generating Modules

In addition to any Protection installed by the Generator to meet his own requirements and statutory obligations on him, the Generator must install Protection to achieve the following objectives:

i. For all Power Generating Modules:

a. To disconnect the Power Generating Module from the System when a System abnormality occurs that results in an unacceptable deviation of the Frequency or voltage at the Connection Point;

b. To ensure the automatic disconnection of the Power Generating Module, or where there is constant supervision of an installation, the operation of an alarm with an audio and visual indication, in the event of any failure of supplies to the protective equipment that would inhibit its correct operation.

ii. For polyphase Power Generating Modules

a. To inhibit connection of Power Generating Modules to the System unless all phases of the DNO’s Distribution System are present and within the agreed ranges of Protection settings;

b. To disconnect the Power Generating Module from the System in the event of the loss of one or more phases of the DNO’s Distribution System;

Distribution Code (Distribution Planning and Connection Code)

DPC7.4.7 Frequency Sensitive Relays

It is conceivable that a part of the DNO’s Distribution System, to which Embedded Generators are connected can, during emergency conditions, become detached from the rest of the System. It will be necessary for the DNO to decide, dependent on local network conditions, if it is desirable for the Embedded Generators to continue to generate onto the islanded DNO’s Distribution System. If no facilities exist for the subsequent resynchronisation with the rest of the DNO’s Distribution System then the Embedded Generator will under DNO instruction, ensure that the Power Generating Module and/or Embedded Transmission System is disconnected for re-synchronisation.

Distribution Code (Distribution Planning and Connection Code)

Section DPC7.4.7 appears to allow for islanded mode operation during emergency conditions, at the DNO's discretion. In addition, the recently modified version of the requirements for generators (G99) makes explicit provision for islanded mode (see later in this section). We propose to consider engagement with the Distribution Code modification panel about this text, and what would be required to expand the emergency condition to allow for intentional islanding.

As previously mentioned in section 4.2.2, the Distribution Code covers the technical aspects relating to the connection and use of distribution network licensees. The Distribution Code aim to provide standards to ensure safe operation for people and property. According to DPC 7.4.3.5 of Protection Requirements set the obligation for power generation modules to comply with the recommendation in EREC G59 (now replaced with G99).

DPC7.4.3.5 The underfrequency and overfrequency Protection settings set out in EREC G59 paragraph 10.5.7.1 also apply to Power Generating Modules in an Embedded Power Station of Registered Capacity of less than 50MW and at or above 5 MW already existing on or before 1 August 2010, except where single stage Frequency Protection relays are used, in which case the following settings apply.

Protection Function	Setting	Time
U/F	47.5Hz	0.5 s
O/F	51.5Hz	0.5 s

In exceptional circumstances Generators have the option to agree alternative settings with the DNO if there are valid justifications in that the Power Generating Module may become unstable or suffer damage with the settings specified above. The agreed settings should be recorded in the Connection Agreement.

Distribution Code, Distribution Planning and Connection Code, section 7

The Engineering Recommendation (EREC) G99 is the set of regulations surrounding the connection of any generator to the main electrical utility grid. G99 is a recent modification to G59 called "Recommendation for the connection of generation plant to the Distribution System of Licensed Distribution Network Operators", which was initially written by a representative of the Electricity Council Association and Area Electricity Boards who have been replaced by the Energy Network Association [65]. The main purpose of G99 is to address all technical aspects of the connection process from standards of functionality to site commissioning. According to EREC G99 [65], the G99 compliant Mains Protective Relay is an electronic monitoring device which looks at the quality and stability of the utility grid. The relay prevents embedded generator from feeding electricity down in case of loss of main and automatically disconnect and shut down generator from the network.

10.1.1 The main function of the protection systems and settings described in this document is to prevent the Generating Plant supporting an islanded section of the Distribution System when it would or could pose a hazard to the Distribution System or Customers connected to it. The settings recognize the need to avoid nuisance tripping and therefore require a two-stage approach where practicable, ie to have a long time delay for smaller excursions that may be experienced during normal Distribution System operation, to avoid nuisance tripping, but with a faster trip for greater excursions.

EREC G59/3 Protection

Nevertheless, in the May 2018 the new version of the Engineering Recommendation was produced and replaced G59 for G99 called “Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019”. In these regulations, section 9.6 which outlines the recommendations for an isolated mode of operation of distribution section network with DGs has been provided, as shown below:

9.6.1 A fault or planned outage, which results in the disconnection of a Power Generating Module, together with an associated section of Distribution Network, from the remainder of the Total System, creates the potential for island mode operation. It will be necessary for the DNO to decide, dependent on local network conditions if it is desirable for the Generators to continue to generate onto the islanded DNO’s Distribution Network. The key potential advantage of operating in Island Mode is to maintain continuity of supply to the portion of the Distribution Network containing the Power Generating Module. The principles discussed in this section generally also apply where Power Generating Modules on a Generator’s site is designed to maintain supplies to that site in the event of a failure of the DNO supply.

9.6.2 When considering whether Power Generating Modules can be permitted to operate in island mode, detailed studies need to be undertaken to ensure that the islanded system will remain stable and comply with all statutory obligations and relevant planning standards when separated from the remainder of the Total System. Before operation in island mode can be allowed, a contractual agreement between the DNO and Generator must be in place and the legal liabilities associated with such operation must be carefully considered by the DNO and the Generator. Consideration should be given to the following areas:

(a) load flows, voltage regulation, frequency regulation, voltage unbalance, voltage flicker and harmonic voltage distortion;

(b) earthing arrangements;

(c) short circuit currents and the adequacy of protection arrangements;

(d) System Stability;

(e) resynchronisation to the Total System;

(f) safety of personnel.

EREC G99/1 Section 9 Network Connection Design and Operation

Under this recommendation, power generation modules embedded in the distribution network could operate under islanded conditions to maintain uninterrupted supply to a customer within the network. Further, G99 sets out that the conditions should be met to allow automatic reconnection when the DNO supply is restored without interrupting customer connection. Also, the special arrangements when necessary would be additionally discussed with DNO. In summary, G99 reduce constraints on implementing islanding mode for a section of the distribution network if actions are coordinated with DNO.

4.3.4 Use of system charges methodology

Conceptually, there is a potential impact of network islanding on the methodology for calculation of use of system charges. This is an area that requires further consideration as part of the detailed research, and depends on the technological approaches adopted. However, the potential issue can be summarised as follows:

- Creation of a network island means that the customers and generators within the island will require to be controlled and managed separately from those in the remainder of the network. This begs the question whether the approach to calculating DUoS charges based on volume forecasts and allowed revenues will remain valid;
- Creation of a network island by a DNO is anticipated to mean that the DNO will retain the responsibilities for that portion of network and, hence, its overall forecast volume would be unchanged and it would retain its right to receive the allowed revenue in order to recover its costs;
- Creation of a network island by a DNO is anticipated to mean that the customers within the island will retain their existing relationships with suppliers, but modifications may be required to the balancing and settlement arrangements to cope with additional imbalances that may arise. This issue is discussed in more detail in sub-section 5.3.1.

4.4 Summary

Approaches / Considerations	Islanding to enable greater use of renewable energy resources	Islanding to increase security of supply	Islanding as an alternative to traditional network reinforcement	Islanding to reduce other costs	Islanding as a tool for operating network with greater flexibility and resilience
Requirements	The prevailing documents that make up the regulatory framework must be adhered to by DNOs when implementing network islanding, and no other parties should be caused to fail to comply with their obligations as a result of the DNOs' actions. However, specific derogations may be negotiated with Ofgem, for example for the purpose of a demonstration project. The range of documents includes: • Electricity Distribution Licence; • Distribution Code, including referenced Engineering Recommendations; • Distribution Connection and Use of System Agreement; • Grid Code; • Connection and Use of System Code, including the Bilateral Embedded Generation Agreement; and • Balancing and Settlement Code.				
Barriers	Rules state that DNOs cannot own and operate generation facilities, including storage. The identified ambiguity in the Distribution Code about islanding is a potential barrier. Additionally, the identified potential requirement for	The likelihood that benefits solely be received by those customers within the network island is a barrier.	Same as for: islanding as an alternative to traditional network reinforcement.	The likelihood that benefits would solely be received by those customers within the network island is a barrier.	Same as for: islanding as an alternative to traditional network reinforcement.

Approaches / Considerations	Islanding to enable greater use of renewable energy resources	Islanding to increase security of supply	Islanding as an alternative to traditional network reinforcement	Islanding to reduce other costs	Islanding as a tool for operating network with greater flexibility and resilience
	modification of the BSC is a barrier.				
Possible solution	The rules against DNOs owning and operating generation facilities can be overcome through adoption of hybrid ownership models in line with international examples. Whilst there is ambiguity in the text of the Distribution Code, the recent modification of the requirements for generators (G99) appears to make explicit provision for network islanding. Additionally, the identified potential requirement for modification of the BSC is a challenge, but conceptually achievable.	Given the likely difficulty in identifying socialised benefits that may be derived for all customers, it is proposed that this approach is excluded from the subsequent detailed research and analysis phase of the project.	Same as for: islanding as an alternative to traditional network reinforcement.	Given the likely difficulty in identifying socialised benefits that may be derived for all customers, it is proposed that this approach is excluded from the subsequent detailed research and analysis phase of the project.	Same as for: islanding as an alternative to traditional network reinforcement.

5. Research of commercial considerations of network islanding

5.1 Introduction

The following section investigates the commercial considerations for establishing and operating network islands. Operating part of the network as an island could have potential commercial issues due to trading arrangements which could change if generation/customers were to be disconnected from the main network. This section provides an overview of the commercial arrangements in Great Britain, the impact on network islanding and the potential solutions that are available.

5.2 Concepts and requirements

5.2.1 Overarching arrangements

Commercial activities in the sector are governed by the trading arrangements that exist under the BSC, as described in sub-section 4.2.2.

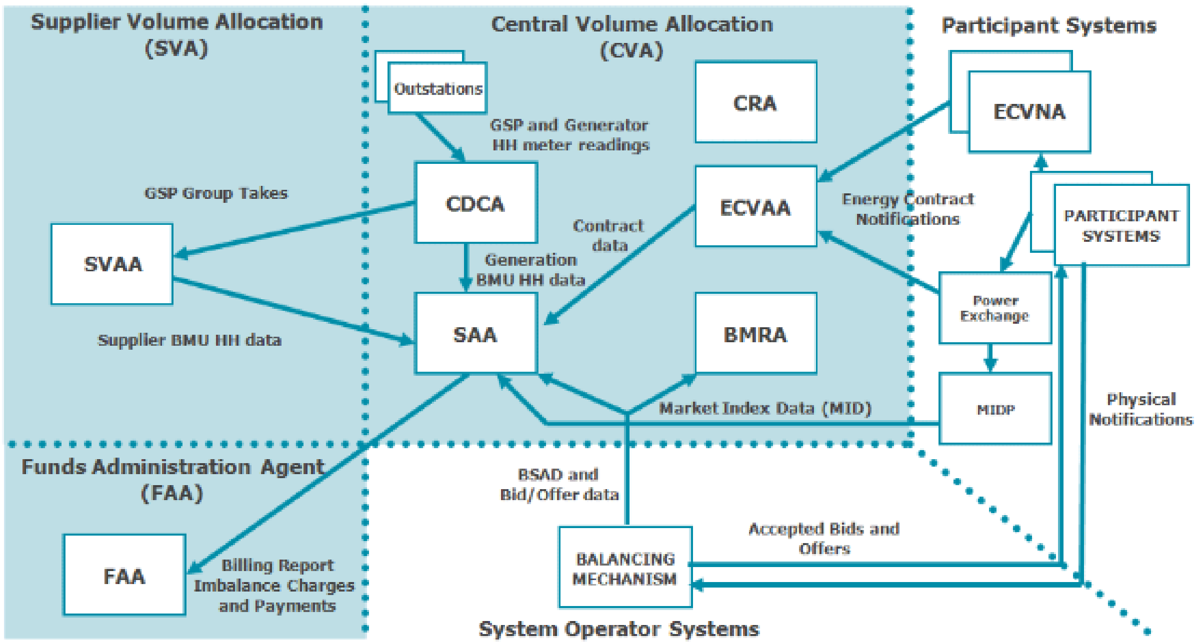
'NETA and BETTA were established to:

- Enable electricity to be traded bilaterally, and ahead of time, between willing buyers and sellers in an open and competitive wholesale market (outside the BSC)
- Ensure that total electricity generation and demand are balanced in real time, through a Balancing Mechanism operated by National Grid as the GB Transmission System Operator
- Establish any differences ('imbalances') between the amounts of electricity which are traded and the actual electricity which is generated/consumed, and ensure that these are paid for, through a post-event imbalance settlement process operated by ELEXON'.

Elexon, history of the BSC [36]

5.2.2 Electricity trading and settlement

As described in the part of sub-section 4.2.2 covering the BSC, there are multiple agents and systems implemented under the BSC. These arrangements are illustrated in Figure 5-1, taken from the guidance provided by Elexon 'knowledgebase' article on trading and settlement [42].



Source: reference [42].

Figure 5-1 Trading and settlement systems

The forwards market mentioned in sub-section 4.2.2, that corresponds to most of the electricity that is traded for each half hour (from one hour ahead up to years in advance), is represented by the upper right portion of the diagram:

- The Energy Contracts Volume Notification Agent (ECVNA) takes information from generators' and suppliers' participant systems about the bilateral trades that they have agreed upon. This information is passed to the Energy Contract Volume Aggregation Agent (ECVAA) along with that from the power exchanges which are used as an alternative to bilateral agreements;
- Thus, the ECVAA computes the aggregate volumes from the numerous bilateral and power exchange market trades, and provides these to the Settlement Administrator Agent along with financial details of the trades.

The balancing mechanism (BM), that exists to allow the ESO to evaluate financial bids and offers from generators to increase or decrease their outputs, respectively, in order to balance the system, is shown in the centre at the bottom of the diagram:

- Information flows in both directions between the BM system and the participants' systems (to allow them to make decisions);
- Information about accepted bids and offers is passed to the Balancing Mechanism Reporting Agent (BMRA) and the SAA.

Metering data is also required to allow the SAA system to reconcile all of the contracts and the imbalance that is resolved through the BM:

- The Central Data Collection Agent (CDCA) receives half-hourly meter readings from the outstations (grid supply points, GSPs, and generator terminals);
- The CDCA transfers the half-hourly data from the generator meter readings to the SAA, and the data from GSPs to the Supplier Volume Allocation Agent (SVAA);
- The SVAA determines the overall supplier half-hourly data (using assumptions to account for customers with non-half hourly meter readings) and passes this information back to the SAA.

The SAA reconciles all of the information that it receives and calculates the financial implications of the imbalances that have been resolved through the balancing mechanism. It passes this information to the Funds Administration Agent (FAA) who deals with the resulting transactions.

5.2.3 Arrangements relating to embedded generation

As stated in sub-section 4.2.2, under the CUSC small and medium embedded generators are required to enter into the BEGA contract. This places obligations on the generator with regard to Transmission Entry Capacity and registration of BM Units to operate in the balancing mechanism under the BSC. The relevant section of the BEGA is as follows:

> ‘7. TRANSMISSION ENTRY CAPACITY
>
> 7.1 The Transmission Entry Capacity of [each of the] site[s] of Connection is [are] and the[ir] value[s] for the purposes of Paragraph 3.2 of the CUSC are specified in Appendix C.
>
> 7.2 Appendix C Part 3 will set out the BM Unit Identifiers of the BM Units registered at the Connection Site under the Balancing and Settlement Code. The User will provide The Company with the information needed to complete details of these BM Unit Identifiers as soon as practicable after the date hereof and thereafter in association with any request to modify the Transmission Entry Capacity and The Company shall prepare and issue a revised Appendix C incorporating this information. The User shall notify The Company prior to any alteration in the BM Unit Identifiers and The Company shall prepare and issue a revised Appendix C incorporating this information.’
>
> **Bilateral Embedded Generation Agreement (BEGA), section 7**

5.3 Discussion about barriers and potential solutions

5.3.1 Commercial issues driven by regulations

The regulatory regime plays an important role in defining the commercial framework within which companies operate in the electricity sector. There is a need to balance consumer interests (low bills) with the ability of companies to operate sustainably (with an acceptable level of profit) and the longevity of the infrastructure that makes up the sector (requiring investment). The regulator acts to maintain competition where possible, and to implement measures such as price controls where it is not.

Network islanding has the potential to disrupt the existing commercial framework because it creates new responsibilities and requires organisations to behave differently. Such changes to take on more responsibilities generally result in higher costs to businesses, so there is a commercial barrier. However, as time passes the direct and indirect financial benefits of network islanding should become clearer which would counter this argument. Additionally, there are indications from the work to plan a smart and flexible system [25], discussed in sub-section 4.2.5, that barriers to solutions such as network islanding will be reduced in the future.

Sub-section 4.3.4 identified that modifications may be required to the balancing and settlement arrangements to cope with additional imbalances that may arise from network islanding. This represents a barrier since it may be difficult to modify the BSC or the complex systems that are implemented under it. However, based on high level research we consider that it is conceptually possible to implement additional calculations and data transfer paths to undertake the analyses for the settlement of additional imbalances that arise from network islanding. Such modifications may be required within the SVAA system or through the addition of a new agent. In any case, the modifications would need to be sufficiently flexible to cope with:

- Islands in different locations;
- Transitions from grid-connected to islanded mode operation and back again; and
- Different durations of islanded mode operation.

5.3.2 Impact of network islanding on existing charging methodologies and ability to recover costs

As identified in sub-section 4.3.4, there is a potential issue if network islanding changes actual consumption a great deal from the volume forecasts. If this is the case then the approach to calculating DUoS charges based on volume forecasts and allowed revenues may not remain valid. This is a commercial issue relating to the ability of DNOs to recover their costs, and a solution would need to be found.

However, as stated in sub-section 4.3.4, the creation of network islands by DNOs is anticipated to mean that both the DNOs and suppliers retain their responsibilities. As such, the overall forecast volumes should remain unchanged. Imbalances from using different generation to supply the demand when islanded should be reconciled through the BSC systems.

5.3.3 Ability of DNOs to derive socialised benefits

In order for DNOs to justify implementation of network islands intentionally, it will be necessary to demonstrate some benefits that may be socialised across all of the DNOs' customers. It would be inappropriate for DNOs to take actions that benefit limited groups of customers and, in all likelihood, penalise other customers. This would be the case under the two approaches that were excluded at the end of section 4.

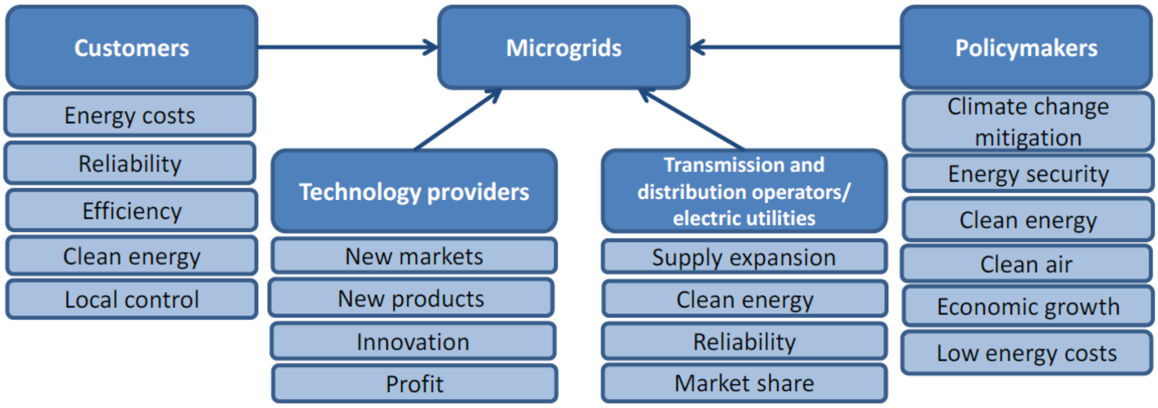
Whilst the available references do not provide sufficient information to determine precise benefits, it is indicated that potential socialised benefits may be derived from islanding under the following approaches:

- Islanding to enable greater use of renewable energy resources;
- Islanding as an alternative to traditional network reinforcement; and
- Islanding as a tool for operating network with greater flexibility and resilience.

5.4 Potential financial benefits

5.4.1 Range of benefits to different parties

The following figure, taken from 'International Microgrid Assessment: Governance, INcentives, and Experience (IMAGINE)' paper in the ECEEE 2013 Summer Study Proceedings [21], shows the range of drivers for different parties to implement microgrids. It is presented to illustrate the relationships between drivers and benefits that are explored in Table 5-1, along with means of monetisation to give financial benefits where appropriate.



Source: reference [21]

Figure 5-2 Range of drivers for network islanding

The following benefits can be considered to have potential to be socialised:

Table 5-1 Relationships between drivers and benefits

Driver	Corresponding benefit associated with network islanding	Potential means of monetisation of benefit
Supply expansion	Reduced need for traditional reinforcements	Avoided capital costs of traditional reinforcements
Clean energy	Increased use of renewable generation sources	Avoided costs of alternative climate change mitigation measures; Avoided costs of penalties associated with GHG emissions.
Flexibility (local control; clean energy; new products; innovation; reliability; low energy costs)	Additional flexibility tool	Potentially from redirection of revenues from DSO flexibility services markets, e.g. Piclo Flexibility Marketplace [66].

5.4.2 Impact of intentional islanding of DG on electricity market prices

The effect of islanding a section of distribution network has been examined in the paper [67] which focuses on the influence of safe, intentional islanding on close-to-real-time electricity prices. In the scenarios described in the paper, the market clearing prices are formulated at five minutes intervals based on optimal power flow problems with a requirement to simulation the outcome of islanding.

The challenge of creating an operational model of the islanded network is to simulate "congestion management scheme", and market participants might submit bids for generation or load. It is anticipated that the region with surplus generation might have lower prices, whereas regions with power deficiency would have higher prices [67]. In the analysis, the following situation of system operation considering islanding were studied to present possible outcomes of DG islanding in an electricity market:

- Base case of normal operation of the network (see network topology in Figure 5-3).
- Current practice following a disturbance (applied between bus 5 and bus 7) results in prevention of islanding and blackout.
- Intentional islanding with deficit capacity in the islanded distribution network (with DGs). In this case, a split system of price areas takes into consideration the costs of the unserved load.
- Intentional islanding with excess capacity in the islanded distribution network (with DGs).

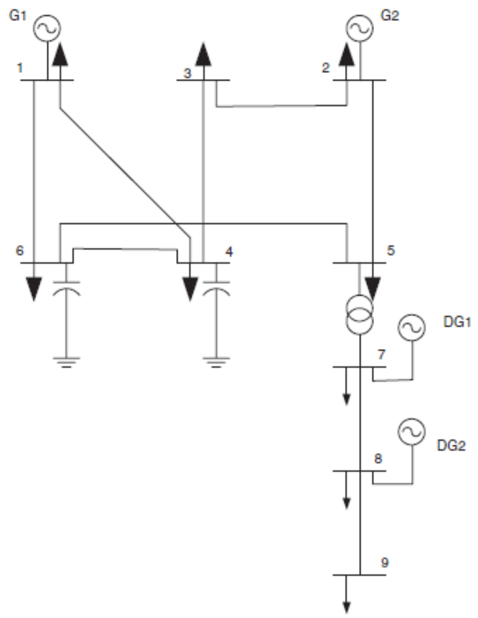
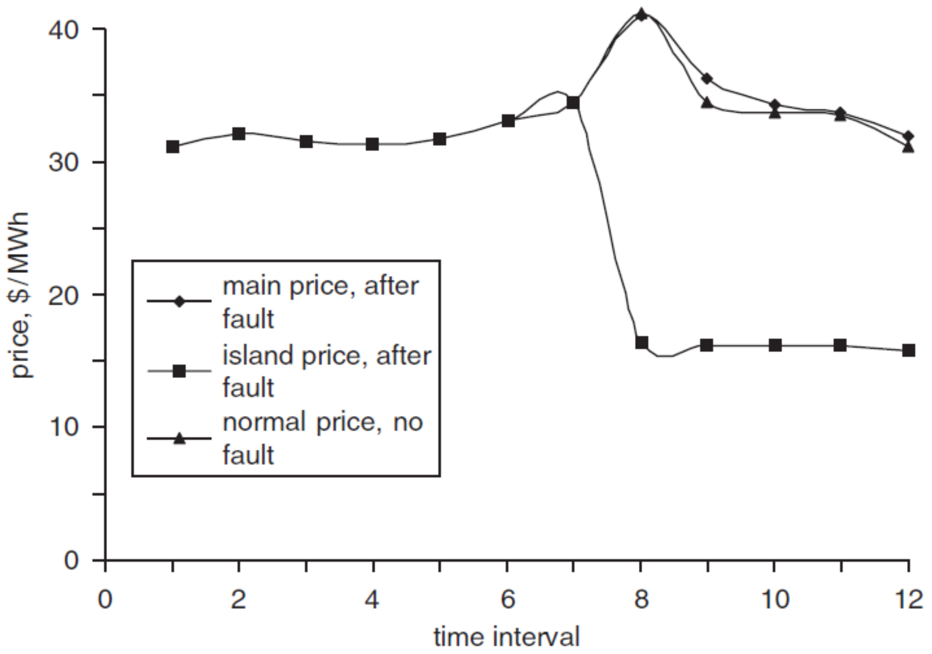


Figure 5-3 Effect of islanding on DG electricity market prices

The results achieved in the study indicate a reduction of electricity market prices during a disturbance between bus 5 and 7, whether the distribution system is disconnected with DGs or is operating in islanded mode with DG supplying power. However, islanded system prices are directly affected by the state of the system after a fault and market price with intentional islanding is reduced significantly (see Figure 5-4)



Source: [67]

Figure 5-4 Results of the simulation of market prices for the system with intentional islanding.

Based on the analysis, the paper concludes that islanding should combined with demand flexibility to prevent unserved loads. By decreasing load profiles during islanding, a reduction in market price could be achieved [67]. From the previous literature review, load shedding is commonly applied to satisfy power flow balancing in the network. As highlighted in the literature [67], before network islanding can be considered robust rules and regulations should be in place to facilitate the safe and reliable operation of the network. These should prevent third parties or DG owners from taking advantage of an islanding mode to dominate market prices in a non-competitive environment.

5.5 Summary

Approaches / Considerations	Islanding to enable greater use of renewable energy resources	Islanding as an alternative to traditional network reinforcement	Islanding as a tool for operating network with greater flexibility and resilience	Islanding to increase security of supply	Islanding to reduce other costs
Requirements	It is assumed that DNOs would be required to operate network islands within the existing framework established under the BSC, and that DG would continue to meet its obligations under the Grid Code, CUSC, etc. It is envisaged that some changes will need to be made to the BSC, or its systems. The nature if these modifications will be reviewed during the next phase of the project.			Excluded	Excluded
Barriers	The potential requirement to modify the BSC or the complex systems that are implemented under has been identified as a barrier. Additionally, the potential issue of the use of system charges methodology being undermined if network islanding changes actual consumption a great deal from the volume forecasts has been identified as a barrier. Finally, the ability of DNOs to identify socialised benefits where financial benefits can be shared between all customers has been identified as a potential barrier.				

Approaches / Considerations	Islanding to enable greater use of renewable energy resources	Islanding as an alternative to traditional network reinforcement	Islanding as a tool for operating network with greater flexibility and resilience	Islanding to increase security of supply	Islanding to reduce other costs
Possible solution	Based on high level research we consider that it is conceptually possible to implement additional calculations and data transfer paths to undertake the analyses for the settlement of additional imbalances that arise from network islanding. It is anticipated that both the DNOs and suppliers will retain their responsibilities when islands are created. As such, the overall forecast volumes and use of system charges calculations should remain unchanged. Whilst the available references do not provide sufficient information to determine precise benefits, it is indicated that potential socialised benefits may be derived from islanding under these approaches.				
Potential financial benefits	Avoided costs of alternative climate change mitigation measures	Avoided capital costs of traditional reinforcements	Potentially from redirection of revenues from DSO flexibility services markets, e.g. Piclo Flexibility Marketplace		

6. Assessment of network islanding approaches

6.1 Introduction

The assessment of islanding approaches presented in this section has been undertaken consistently with the methodology adopted in the high level review report on technical considerations. The assessment is essentially a binary statement of our judgement of the feasibility of each approach.

The high level review report presented an indicative methodology for the assessment and scoring of islanding approaches based on a range of indicators. It is judged that it is not appropriate to adopt this methodology at the current time, due to the limited information available from sources. However, it is envisaged that the indicative methodology will be adapted to be employed as part of subsequent more detailed investigations to update the high-level feasibility study presented in section 7.

6.2 Assessment

Table 6-1 presents the results of the assessment of islanding approaches in tabular form.

The high level review report identified potential approaches and presented the research about the technical considerations of network islanding. That report concluded that all five approaches are technically feasible.

Following the research of legal, regulatory and commercial considerations presented in this report, we must again conclude that, notwithstanding challenges, it would be feasible to implement network islanding under each of the five approaches. However, the 'summary of principal considerations' row indicates that the following approaches align less well with the obligations and objectives of WPD as a DNO operating in GB. Thus, in our view there would be more significant challenges associated with implementing islanding under these approaches and they will, therefore, be excluded from subsequent assessment and detailed research in the next phase of the project:

- Islanding to reduce other costs; and
- Islanding to increase security of supply.

Table 6-1 Assessment of islanding approaches

Approaches / Considerations	Islanding to enable greater use of renewable energy resources	Islanding to increase security of supply	Islanding as an alternative to traditional network reinforcement	Islanding to reduce other costs	Islanding as a tool for operating network with greater flexibility and resilience
Technical	Feasible	Feasible	Feasible	Feasible	Feasible
Legal	Feasible	Excluded	Feasible	Excluded	Feasible
Regulatory	Feasible	Excluded	Feasible	Excluded	Feasible
Commercial	Feasible	Excluded	Feasible	Excluded	Feasible

7. Feasibility study considerations

7.1 Introduction

Available sources provide limited quantitative information about direct financial and other benefits. The time available for this high level research phase of the project has not permitted us to undertake more detailed investigation to derive quantitative values for the identified benefits, including monetisation of indirect benefits. Neither has it been possible to consider the equivalent counterfactual cases for comparison with the islanding approaches in any detail. However, the following sub-sections provide high level commentary about the areas for investigation and steps that will be undertaken in the next phase of the project, for each of the islanding approaches taken forward.

For the approaches selected to be taken forward, each of the following areas will be considered in detail in the next phase of the project:

- Financial costs and benefits;
- Environmental benefits;
- Capacity benefits.

7.2 Approach 1: Islanding to enable greater use of renewable energy resources

Figure 7-1 presents the conceptual basis for this approach. It shows two potential islands that may be created by the DNO through its control system that undertakes system studies to inform decisions. The selected islands may be “redrawn” according to online studies that determine the needs of the system.

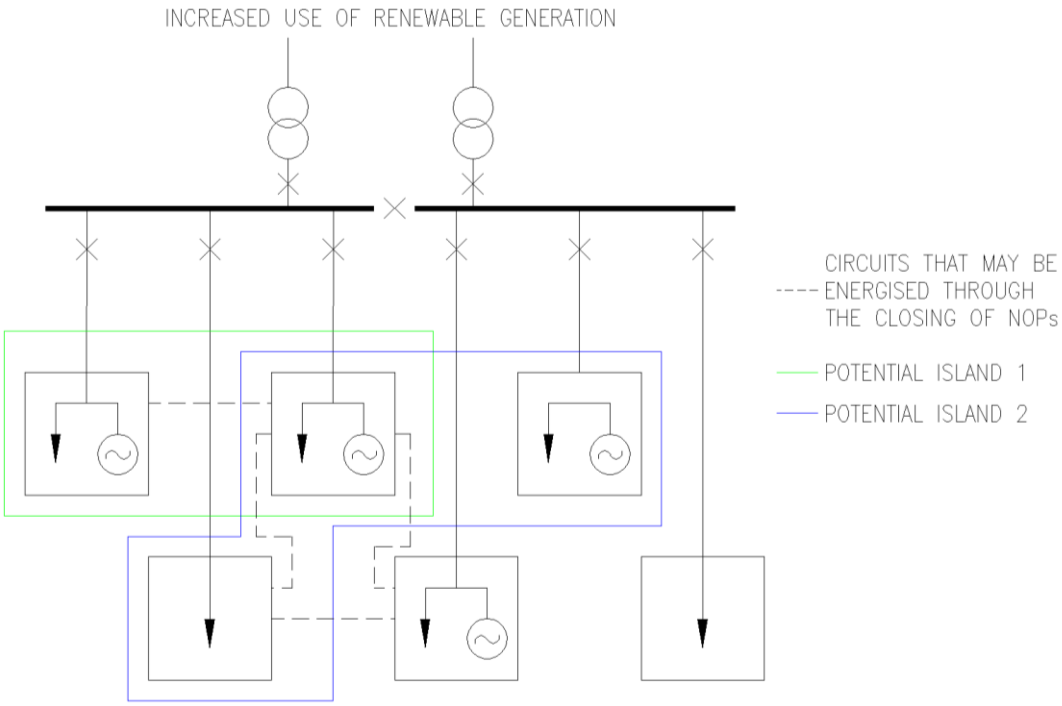


Figure 7-1 Conceptual diagram illustrating islanding for increased use of renewable generation

It is anticipated that the primary benefit from this approach will be derived through the relief of network constraints and the resulting ability to dispatch and export more power from renewable generators (combination of those inside and outside of the island). This results in indirect carbon emissions reduction and capacity release benefits that may be monetised using commonly used assumptions.

7.3 Approach 2: Islanding as an alternative to traditional network reinforcement

Figure 7-2 presents the conceptual basis for this approach. It shows a restricted section of network and two DG plant with the potential to avoid traditional reinforcements to support the reverse flow of power from the DG up through the network if it can be consumed locally within an island.

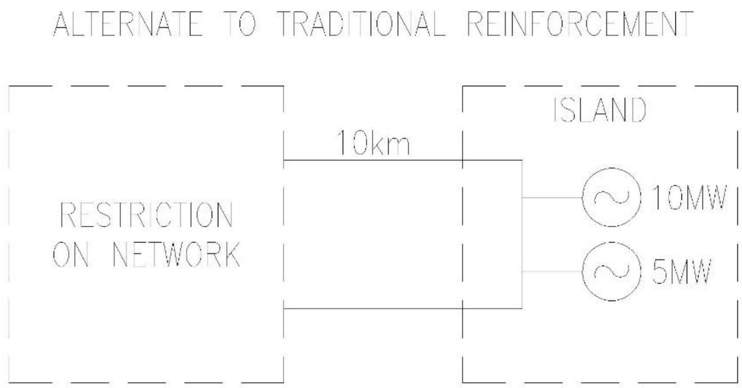


Figure 7-2 Conceptual diagram illustrating islanding as an alternative to traditional network reinforcement

The principal potential benefit of this approach is the avoided cost of reinforcement which is a direct financial benefit.

7.4 Approach 3: Islanding as a tool for operating network with greater flexibility and resilience

The precise nature of this approach is not clear due to the uncertainty about the outcomes of the changes to the legal and regulatory environment for flexibility, including the roles, responsibilities and supporting systems.

8. Conclusion

8.1 Findings

This report presents the research of the legal, regulatory and commercial considerations for the approaches to network islanding that were identified in the high level review report. In each area, the research covers: concepts and requirements; and discussion of barriers and possible solutions. The research of the commercial considerations additionally includes potential financial benefits. The report also presents the simple (binary) assessment of the approaches to be carried forward in the project, and a discussion of the considerations for the completion of the Feasibility Study in the next phase of the project.

From the previous report it is clear that creating and operating network islands is technically feasible. The research presented in this report excludes two of the identified approaches (islanding to increase security of supply; and islanding to reduce other costs) on the grounds of increased regulatory/commercial barriers. This does not mean that these approaches are not viable applications of network islanding, but rather that they have been excluded from our subsequent research since they are less suitable for adoption by DNOs.

This leaves three remaining approaches that will be considered in the subsequent detailed research phase, which will be supported by the results of some simple system studies:

- Islanding to enable greater use of renewable energy resources;
- Islanding as an alternative to traditional network reinforcement; and
- Islanding as a tool for operating network with greater flexibility and resilience.

A number of barriers to network islanding and possible solutions to overcome them have been captured and discussed within the report. These will help to inform the further research in the next phase of the project.

In summary, three network islanding approaches appear to be viable, following research of technical, legal, regulatory and commercial considerations. Subject to confirmation during the detailed research phase, these approaches have potential for DNOs/DSOs to release financial, carbon and capacity benefits.

8.2 Next steps

The work undertaken as part of this high level research task represents a significant amount of learning that will inform future work. In the next task the following items will be explored:

- Legal
  - Engage with ongoing activities led by Ofgem (consultations), and work under the Smarter Systems and Flexibility Plan, including the Open Networks Project, to carry out detailed research into likely developments regarding relevant legal definitions;
- Regulation
  - Further research of the regulatory implications of the of hybrid ownership model for DNOs/DSOs to interact with third party owners of generation, and establish appropriate arrangements for system control and operation;
  - Further research and possible engagement with the Distribution Code modification panel regarding the inconsistency within the Distribution Code and implications of the recent modification of the requirements for generators (G99);
  - Further research about the nature of potential modifications to the BSC;

- Commercial
  - Further research about the nature of potential modifications to the BSC systems (additional calculations and data transfer paths) to undertake the analyses for the settlement of additional imbalances that arise from network islanding.
  - Further research about the precise nature of the benefits of the three approaches, to be presented in the Feasibility Study.

In addition to those items listed above, further work will be undertaken to study and understand what parts of the WPD network could potentially be operated as a network island. Considering network islanding approaches on real trial area networks will allow for calculation of potential financial, carbon and capacity benefits.

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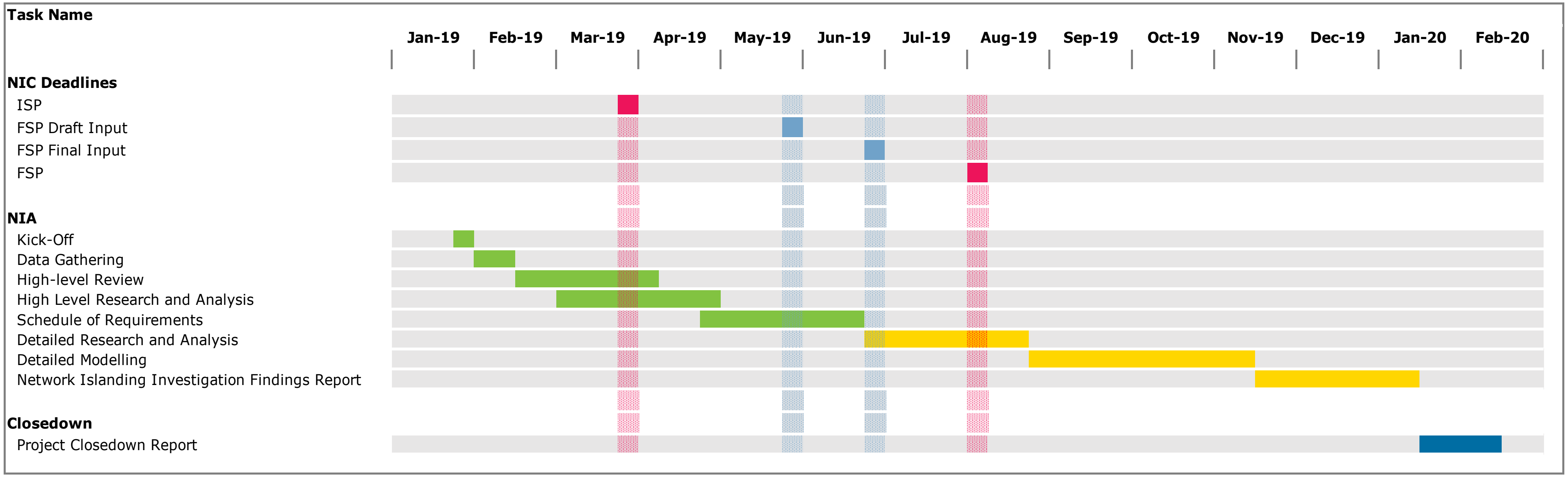
Appendices

Appendix A – Gantt Chart



Appendix B – High level review report

The high level review report is provided below for reference.

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