ICE REPORT 2.4.4

ICE GENERAL METHODOLOGY VALIDATION STUDY: ISLES OF SCILLY

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About ICE

Supported by Interreg VA France (Channel) England, the Intelligent Community Energy (ICE) project, aims to design and implement innovative smart energy solutions for isolated territories in the Channel area. Islands and isolated communities face unique energy challenges. Many islands have no connection to wider electricity distribution systems and are dependent on imported energy supplies, typically fossil fuel driven. The energy systems that isolated communities depend on tend to be less reliable, more expensive and have more associated greenhouse gas (GHG) emissions than mainland grid systems. In response to these problems, the ICE project considers the entire energy cycle, from production to consumption, and integrates new and established technologies in order to deliver innovative energy system solutions. These solutions will be implemented and tested at our unique pilot demonstration sites (Ushant island and the University of East Anglia's campus), to demonstrate their feasibility and to develop a general model for isolated smart energy systems elsewhere. The ICE consortium brings together researcher and business support organisations in France and the UK, and engagement with SMEs will support project rollout and promote European cooperation.

Isles of Scilly: ICE General Methodology Validation Study

1 Introduction: purpose of this report

This report contributes to fulfilment of task 2.4 of the ICE project. The objective is to provide empirical validation of the 'ICE General Methodology' developed in task 2.1 and presented in report T.2.1.2 through application to four alternative sites. The objective of the task is to consider how the application of the methodology may be affected by local considerations and to suggest refinements to the general methodology where required.

The sites are:

- Chausey, France (report 2.4.1)
- Molène, France (report 2.4.2)
- Lundy, UK (report 2.4.3)
- Isles of Scilly, UK (this report, 2.4.4)

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2 Smart energy transition on the Isles of Scilly

2.1 Island overview

The Isles of Scilly (IoS) are a small cluster of islands to the west of Cornwall. It is an archipelago of around 140 islands, around 45km west of Land's End, Cornwall. Five are inhabited: St Mary's, Tresco, Bryher, St Martin's and St Agnes (Royal Haskoning, Cornwall Council, and Isles of Scilly Council, 2011). The largest inhabited island is St Mary's which is the main settlement of the islands.

2.2 Reasons for selection

Among the many challenges facing sustainable energy transition on small islands, the small scale of demand, large seasonal variations in demand, lack of available energy resources and heritage restrictions on development, are particularly prevalent. Furthermore, IoS has a high share of fuel poverty (22.4%, against the national average of 10.4%) (Hitachi Europe Ltd, 2016).

2.3 Demographics and location

The permanent population of the IoS is around 2,324 in 2015 (ONS, 2016). Much of the population is based on the largest Island, St Mary's. The islands receive an estimated 125,000 annual visitors, mainly from May to September as shown in Figure 1**Error! Reference source not found.** (Visit Isles of Scilly, 2019). The location of the IoS is shown in Figure 2.

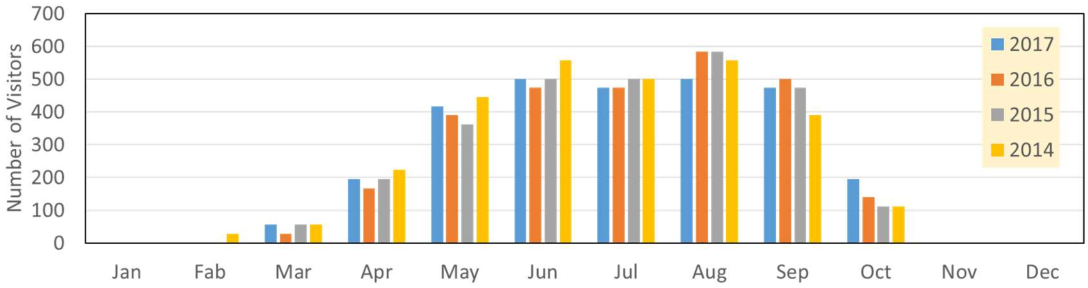

***Figure 1**: Isles of Scilly tourism over a year for four consecutively*

St Martins is the most northerly of the populated Isles of Scilly and lies 2.5km north-northeast of St Mary's. It is surrounded by several smaller uninhabited islands and islets, particularly on its western and southern shores. Tresco and Bryher lie close to one another to the north-west of St Mary's. Bryher, lying to the west of Tresco, is more exposed although its sheltered eastern shoreline has extensive sandy areas. The island of Tresco is to an extent managed separately from the other islands, under a long-term lease from the Duchy. The most southerly of the inhabited Isles is St Agnes. Immediately to the east lies Gugh, a smaller island that is considered along with St Agnes as they are linked by coastal processes (Royal Haskoning, Cornwall Council, and Isles of Scilly Council, 2011).

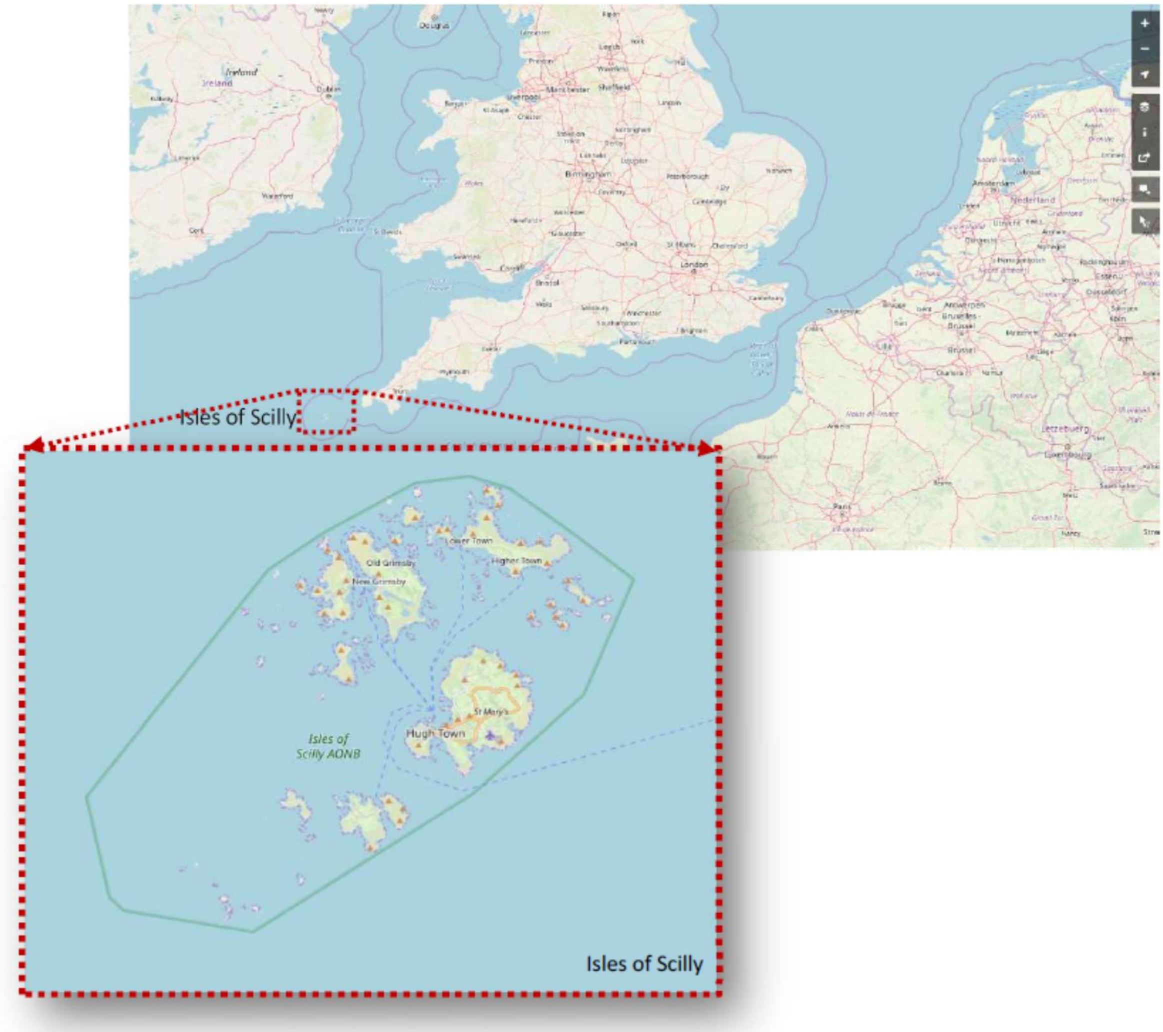

Figure 2: The IoS location

2.4 Economic status

The mild climate of the Isles of Scilly enables the islands to supply early-season flowers to the mainland market. The natural environment of the Isles of Scilly attracted many loyal repeat visitors that support many jobs and businesses. The primary economic activity is associated with tourism, accounting for about 85% of the islands' income (Isles of Scilly Council, 2019). For instance, in 2008, visitors spent £29.5 million on the Isles of Scilly (Ash Futures, 2014). The majority of visitors stay on St Mary's. Tresco is run as a timeshare resort. Bryher and St Martin's are more less developed. St Agnes has no hotel and it is the least developed of the inhabited islands. Over time, industries such as kelp harvesting, pilotage, fishing and shipbuilding have contibuted to the island economy (Isles of Scilly Council, 2019).

2.5 Policy and regulatory overview

The following subsections summarise relevant policy and regulatory information from ICE report T1.1.2 (Fitch-Roy and Connor, 2018) covering renewable energy routes to market, network and grid access and social and environmental permitting.

2.5.1 Routes to market: RE production, offtake and remuneration

Renewable energy output remuneration policies

Following the staged closure to new projects of the renewables obligation (RO) quota system in March 2017, and the closing of the Feed-In Tariff to new entrants in April 2019, there is only one principle financial support mechanisms for renewable electricity in the UK: Contracts for Difference.

Contracts for Difference

Conceived in 2011 as an element of electricity market reform (EMR), the contracts for difference (CfD) mechanism is the UK's main financial support instrument for large-scale 'low carbon' generation, including renewable energy (DECC, 2011). The instrument is a form of sliding premium, designed to offer a payment in addition to wholesale electricity market revenues up to a fixed 'strike price'. The strike price is set through competitive tenders (Fitch-Roy and Woodman, 2016). The CfD auctions held to date have allowed participation of a range of renewable energy technologies divided into two categories of more and less mature technologies. Onshore wind was excluded from the second and third auction due to a political commitment from the governing political party. The auctions have resulted in the contracting of a large volume of renewable energy, mostly offshore wind (DECC, 2015; BEIS, 2017). It is unlikely that a project scaled for use on Lundy would be economuically viable within the CFD.

2.5.2 Network access and grid connection

Generators gain access to the GB electricity networks through contracts with either the TSO, in the case of large, transmission-connected plant or one of 14 distribution network owners (DNOs). Concerning these small generators in particular, the cost, time involved, transparency and difficulty of obtaining a grid connection offer – and then securing a functioning connection – from DNOs has posed some challenges for some generators, especially small renewable generators. Efforts have been made by the regulator, however, to make the process more efficient, which to-date have proved largely unsuccessful, leading the regulator to explore punitive measures (Ofgem, 2014, 2017).

2.5.3 Social and environmental permits, licences and land-use planning

Under the Town and Country Planning Act (1990), local planning authorities are responsible for issuing permits to developments with installed capacity of less than 50MW. The level of local engagement required to gain permission to build new renewable installations means that planning policy in the UK tends to favour projects that are either wholly or partly owned by community initiatives. Since 2015, the necessity of local involvement in approving areas for wind energy in particular, has been explicit, making wind energy development very challenging in many areas, setting a clear division between onshore wind energy and other renewable energy technologies (DCLG, 2015a; Smith, 2016). However, some opportunities for very small installations on existing buildings remain under what are known as 'permitted development rights' (Smith, 2016). For projects larger than 50MW, the Planning Act (2008) allows decisions to be taken by the responsible minister with local planning authorities contributing through formal consultation (DCLG, 2015b).

2.5.4 'Smart grids' policy

The UK has implemented or is in the process of implementing a number of policy and regulatory changes with the goal of fostering a 'smart and flexible' energy system (BEIS, 2021). Enabling smarter grids is seen by government, regulators and other stakeholders as essential to facilitating increasing volumes of intermittent and distributed low carbon technologies by allowing system wide adoption of new ‘smart’ technologies, more active network management and opening markets to services and technologies that will increasingly include demand side action (Jenkins, Long and Wu, 2015). The UK Government has taken a number of actions already to facilitate change in the UK’s regulation of markets and networks to meet the needs of the low carbon transition and many of these will have implications for opportunities for increased network smartness. The Government, in partnership with energy markets regulator, Ofgem, established the Smart Grid Forum (SGF) in 2014. The SGF has worked closely with electricity sector stakeholders to devise actions to identify all areas requiring action to facilitate smart grid evolution.

2.5.5 Policy for Future Smart Networks

Significant actions already undertaken include a change in incentive structures for the transmission and distribution companies, to try to drive greater network innovation and to allow greater flexibility in terms of investment and return on smart network management approaches rather than simply expanding physical networks. Ofgem also permits network companies to commit additional spending to network innovation through various programmes, including the Low Carbon Network Fund, the Electricity Network Innovation Competition (ENIC) and the Network Innovation Allowance (NIA). Essentially, their aim is to allow the network companies to explore smarter solutions to integrating large volumes of low carbon technology, while minimising cost and maintaining reliability (Connor *et al.*, 2014; Jenkins, Long and Wu, 2015).

The Government has recently announced changes that will have significant further implications for distribution networks. with the announcement that the current, largely passive, distribution network owner (DNO) model will switch to a more active ‘distribution system operator’ (DSO) model (Ofgem, 2019; BEIS, 2021). The Open Networks Project is an initiative of the energy sector aiming to determine what changes are needed, including the changing interaction between transmission and distribution, impact on consumers, and charging issues, as well as the DNO to DSO transition (Energy Networks Association, 2020). The DSO model is common across Europe and the changing role of the DNOs is seem as essential to enabling many of the features likely to be essential to smart grids in the UK (Xenias *et al.*, 2014; BEIS, 2021). Essentially, the shift would see DNOs maintain their current responsibilities but have access to a wider range of active network management approaches and be expected to work more closely with the System Operator and Transmission Owners. The UK is engaged in a nationwide effort to replace all domestic and small business electricity and gas meters with smart meters by 2020. The goal is to bring down systemic costs by reducing supplier costs, driving energy efficiency and by enabling new and innovative approaches to network management such as aggregation, time-of-use tariffs. There are substantive hurdles to maximising benefits however, since some rely on behaviour change and some on access to smart meter generated data by companies which do not currently enjoy access. The rollout of smart meters has also been subject to delays and there is thus some way to go to enabling some key smart energy initiatives deriving from smart meters. There are additional barriers to the coming to fruition of some of the potential smart grid services. Further planned actions include (BEIS, 2021):

- Facilitating flexibility from consumers by
    - Enabling smart buildings
    - Enabling smart electric vehicles
    - Enabling smart local energy solutions
- Removing barriers to flexibility on the grid through electricity storage and interconnection
- Reforming markets to reward flexibility

- By 2025, the ESO will be net zero ready, ensuring it has the markets and tools in place to safely operate a zero carbon system.
- The government and Ofgem will ensure that appropriate governance is in place to deliver coordinated and effective flexibility markets.
- Ensure that flexibility technologies can compete effectively in market structures that drive investment in low carbon technologies and ensure capacity adequacy.
- A standardised approach to carbon monitoring and reporting will be implemented.
- Network users will receive better price signals through network access and charging arrangements about where to locate on the network.

It is likely that the need for additional actions beyond this list will emerge as experience with improving systemic smartness grows and as some options prove themselves or are rejected by the various stakeholder groups. This wide selection of overarching policy and regulatory changes are relevant in the case of many sites, though not all will be relevant to Lundy. Potential for demand side initiatives is likely to be limited beyond improvements in energy efficiency, there is potential for the Landmark Trust to act as a producer from different technologies, or via a 'private wires' agreement, to use storage systems to maximise gain from renewable generation, to become a mini-grid operator or to manage its own consumption more cost-effectively. Decisions regarding all of these actions would typically be impacted by the options that the market allows, but this may not apply due to the Landmark Trust's ownership of structures on the island. The wider regulatory architecture, licensing costs, the availability of new market opportunities and the emergence of new actors or divergence of established actors in exploiting them should still be considered however.

2.5.6 Smarter Energy Markets

Ofgem announced a new programme – Smarter Energy Markets (SEM) – in 2013, with the goal of delivering reform in the wider electricity market and enabling smart approaches that would improve competition and enhance consumer protection (Ofgem, 2013). Enhanced DSR and new products and services fall into this category but are likely to be less relevant to Lundy, which is effectively a private wires system of energy provision.

2.6 Key data on energy production and use

The energy system on the IoS is almost entirely reliant on imported electricity from the mainland, with 457 kWp of solar PV installed on the islands which is likely to generate around 2.6% of the total electricity demand (485,791 kWh/year). The IoS are connected to the mainland electricity via a single 33kV cable with a capacity of 7.5MW (installed in 1989 by Western Power Distribution, WPD). The peak loads of around 4.5MW occur in the evenings. The total electricity consumption on the IoS is approximately 18,500 MWh/year and the highest monthly consumption is in April (Hitachi Europe Ltd, 2016). There is no on-island solution for green waste, waste wood and food, where they cannot be sent to the mainland due to the high cost. St Mary's desalination plant suffers from nuisance shutdown due to power supply quality on the end of the line. The electricity distribution network operator (DNO), WPD, states that the number of customers on the system is 1,678 (Godfrey, 2013). There are 1,375 housing units which leaves 303 industrial, commercial and public buildings. The major issues with the current electricity supply relate to the need for a new sub-sea cable from the mainland and a replacement for the back-up power station on St Mary's. IoS energy consumption in 2012 is shown in Table 1. Only half of energy consumption is from electricity which is consumed fairly equally by the industrial & commercial, and domestic sectors. 13% of petroleum products are consumed on transportation which can be decreased if Electrical Vehicle (EV) introduced. Overall, industrial & commercial consumption accounts for half of the energy use on the islands (50.3%) with domestic consumption second (29.8%)

Table 1: Isles of Scilly Energy consumption

Energy sources	Percentage of total consumption	Percentage of sub consumption
Electricity	49.5%	Industrial & commercial 53% Domestic 47%
Petroleum products	38.6%	Industrial & commercial 70% Domestic 17% Road transport 13%
Bioenergy & wastes	6.3%	
Coal	4.9%	
Manufactured fuels	0.7%	

The Council of the Isles of Scilly has committed to a series of objectives for the Smart Islands programme that will be reviewed and refined by the Smart Islands Partnership as follows (Council of the Isles of Scilly, 2016):

- Reduce electricity bills by 40% by 2025
- Generate 40% of the Islands' electricity by renewables by 2025
- Transition to 40% of vehicles being low carbon or electric by 2025

Eighty-two homes have been fitted with renewable energy generation and energy efficiency equipment since July 2018 on the Isles of Scilly – including 70 homes with solar PV panels on roofs. Five other sites also have solar PV panels and a solar garden has been built at St. Mary's Airport. In addition to some air-source heat pumps in homes, there is now 457kW of renewable energy generation installed on the islands (*Smart energy solutions development on the Scillies*, 2019). Moixa, a smart system company, is installing 43.8kWh of battery storage to help optimise the energy system (Volkwyn, 2018).

2.7 Network status

Western Power Distribution (WPD) is the electrical power provider to IoS through a 33kV subsea cable with a capacity of 7.5MW. There is a diesel-fuelled power station which consists of seven individual generation sets on Hospital Lane on St Mary's. They are used for less than 200hours/year. The sub-sea cable is fed from Cornwall and terminated at St Mary's power station, 33 kV. There are four 11kV feeders which supply power to the islands as shown in Figure 3 (Hitachi Europe Ltd, 2016). They are numbered from 41 to 44.

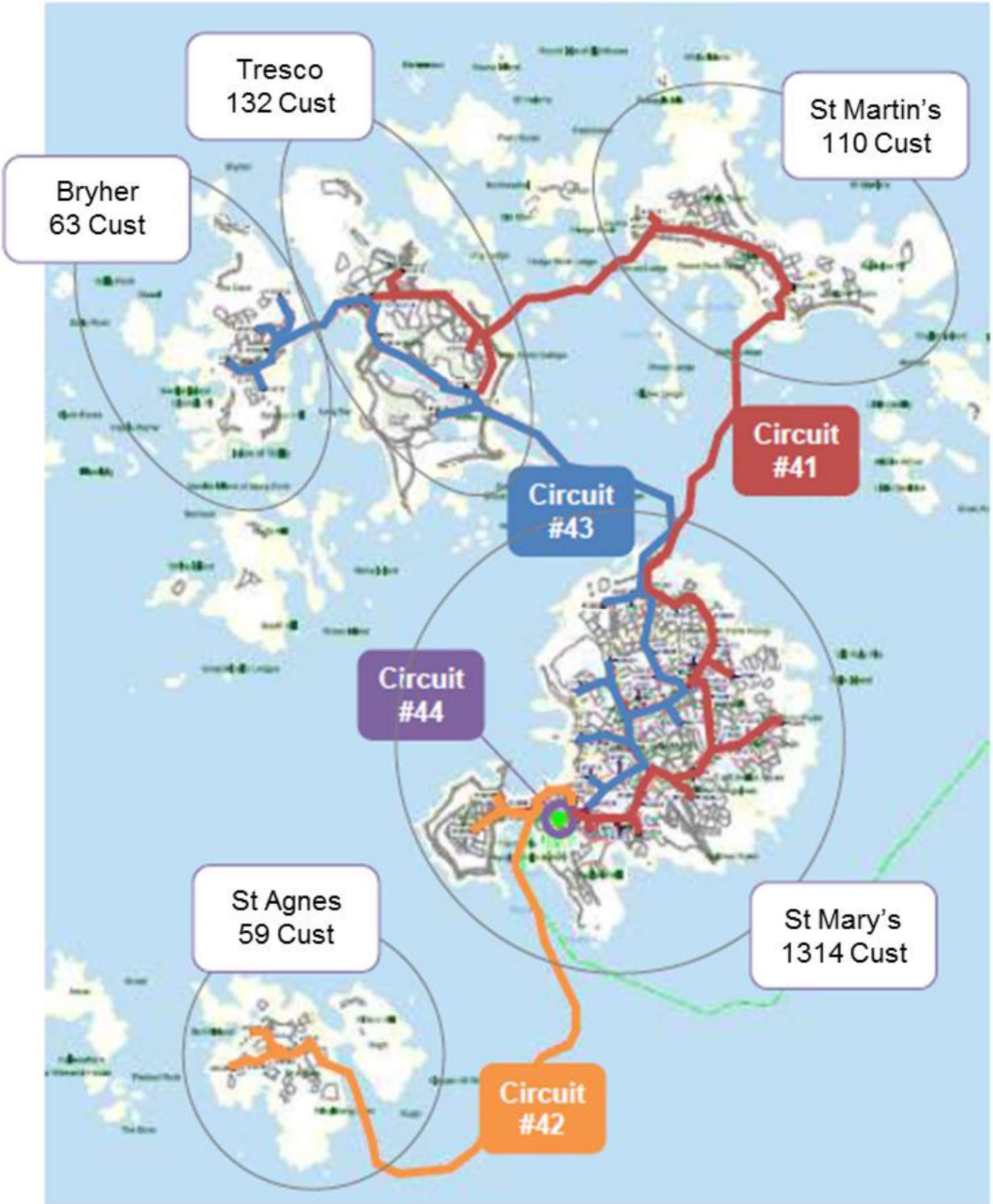

Figure 3: The IoS power network

11kV is the network voltage among islands. It is a mixture of overhead and underground lines on the land and sub-sea cables. The 11kV is converted to a nominal 230V and 415V for consumption via a mixture of ground and sub-sea cables (Hitachi Europe Ltd, 2016). The 33kV cable is a single cable and has historically been reliable. WPD is considering installing a second cable from 2023 which will cost tens of millions GBP (Hitachi Europe Ltd, 2016).

This section examines the applicability, relevance of, and possible challenges to, the seven key elements of the ICE general methodology (GM) developed in ICE report T2.1.2 (Matthew *et al.*, 2018).

3 Stakeholder engagement

The ICE GM identifies two area of importance for stakeholder engagement. The first is the purpose of the engagement and the second is an outline of some broad guidelines for engagement practices.

The purpose of stakeholder engagement is sometimes seen in purely instrumental terms. i.e., a means of obtaining public consent for a particular technological or organisation change. However, change on the scale implied by smart energy transition on an isolated island requires a deeper, and more participatory, deliberative approach in which both the goals of the transition and decisions about the means by which goals are achieved, are the result of open and inclusive discussion among all interested or affected parties. Consideration of approaches tailored to different constituencies is essential to create such meaningful engagement.

The ICE GM strongly suggests that the further 'upstream', or earlier in the decision-making process engagement can occur, the greater the trust between project promoters and the community and, ultimately, the more constructive the engagement. The ICE GM views local communities not as an obstacle to be overcome, but rather a source of knowledge and legitimacy. Engagement is an ongoing relationship that does not stop once a project is completed.

3.1.1 Overview of key principles of GM

The GM therefore:

1. Acknowledges diversity of rationales for both support and opposition to a variety of renewable energy technology options
2. Seeks to ensure that communities have the greatest freedom possible in defining the sustainability challenge at hand, and identifying locally desirable actions
3. Prioritises co-production approaches, where (local) experts (e.g., policymakers, technology and project developers) and publics are brought together to jointly define the problems and potential solutions
4. Considers the needs of various constituencies, with the aim of achieving inclusive and holistic public engagement over the course of energy infrastructure siting
5. Continually engages with stakeholders throughout and beyond the timescale of the project(s)

3.1.2 Limitations to this study

Stakeholder engagement was not possible within this study due to time and resource constraints and severely complicated by the Covid-19 pandemic from February 2020. We were able to integrate some objectives from publicly available documents and through limited communication with the island general manager.

3.1.3 Guiding Principles and Considerations

There is no single recommended approach to public engagement on energy issues and case evidence suggests that public engagement exercises tend to be most effective when they reflect the characteristics of both the project and the local area (Alexander, Wilding and Jacomina Heymans, 2013; de Groot and Bailey, 2016; Dwyer and Bidwell, 2019). Specifically, there are at least five areas of consideration:

- Awareness of and attention to local energy and public engagement history
- Understanding and appropriate inclusion of diversity and difference
- Tailoring participation approaches for the whole community and specific groups
- Ensuring a two-way flow of information and integration of stakeholder input
- Flexibility, transparency and good-faith negotiation in discussing and the determination of community benefits

One important consideration is whether the island has had any previous experiences with engagement processes and energy projects, and how these might influence perceptions of new projects (Alexander, Wilding and Jacomina Heymans, 2013; Papazu, 2016). For example, an unsuccessful wind turbine project on Ushant led to local scepticism towards wind energy on the island. Engagement processes also need to consider the wider issues island communities see as important so that, as far as possible, energy projects enhance the economic, social and cultural fabric of islands and limit any negative effects (Devine-Wright, 2009; de Groot and Bailey, 2016). Wider issues that engagement processes might consider include: employment opportunities; reducing out-migration among younger residents; protecting existing economic sectors like tourism; and ensuring projects respect the local natural and cultural environments (Gross, 2007; de Groot and Bailey, 2016). Understanding people's energy needs is also essential for ensuring that energy projects contribute positively to residents' well-being and energy security and access.

Engagement processes also need to reflect the diverse character of island communities and the potential for differences in opinion between permanent and part-time residents, visitors, and between different economic sectors, such as fishing, agriculture and tourism (Colvin, Witt and Lacey, 2016; Dwyer and Bidwell, 2019). Different engagement strategies and methods may also be needed to engage with groups who, for various reasons, may be unwilling or unable to participate in certain types of engagement activity. Issues of representativeness should also be considered in order, for example, to come to reasoned judgements on how, for example, to consider the views of second homeowners compared with those of lifelong or other permanent residents. Understanding local social structures, power relations, and differences in values is often critical in gaining the trust and cooperation of local communities. Engagement strategies additionally need to incorporate mechanisms that allow groups to express disparate views and manage disagreements. These challenges may be especially pronounced in island communities because some groups (such as part-time residents) may be hard to contact, and because of an aggravated risk of divisions if engagement processes do not pay careful attention to the social dynamics of small communities (Colvin, Witt and Lacey, 2016).

Participation strategies should encourage equitable involvement; however, the techniques used must consider both island community as a whole and the needs and preferences of specific groups. Previous research indicates that more intense engagement processes are not always popular or successful. Sometimes individuals lack the time, confidence, or skills to take a more active role in debating and decision-making on proposals and not everyone will want to be involved. Engagement techniques therefore need to be flexible, pragmatic, and tailored to the needs of each community, and to avoid over-consultation, which can be a particular risk in islands and remote areas with small populations (Haggett, 2011; Aitken, Haggett and Rudolph, 2016; Rudolph, Haggett and Aitken, 2017). Case study evidence shows some preference for workshops (Kerr *et al.*, 2014; Heaslip and Fahy, 2018) and science fairs (Sperling, 2017; Dwyer and Bidwell, 2019) that create relaxed atmospheres for discussions without being onerous for participants.

Wherever possible, engagement processes should involve two-way flows of information (Reed, 2008; Devine-Wright, 2011) that allow dialogue on information provided by engagement organisers (Aitken, Haggett and Rudolph, 2016). Two-way exchanges encourage trust by providing platforms for sharing local knowledge about the physical, economic, political, social, and cultural characteristics of areas that may be unknown to developers and decision-makers, and can then be combined with scientific and technical information to produce more informed decisions (Haggett, 2008; Reed, 2008). Attempts should also be made to act on public and stakeholder concerns, or at least for developers and decision-makers to respond so that residents feel valued in the decision-making process (Sorensen *et al.*, 2002; Gross, 2007; Haggett, 2008; Aitken, Haggett and Rudolph, 2016; Sperling, 2017; Dwyer and Bidwell, 2019). It is important that developers communicate their decisions and rationales for particular courses of action, so that communities feel they are being kept informed, rather than being marginalised once initial consultations have taken place. Developers of the Triton Knoll offshore wind farm shared feedback from pre-application consultations with local stakeholders via a report summarising how consultees' views had been considered in the final application (Aitken, Haggett and Rudolph, 2014). Another way to facilitate information sharing is to use trusted community intermediaries (Klain *et al.*, 2017; Sperling, 2017; Dwyer and Bidwell, 2019). Experience suggests that the context in which information is shared and the person presenting information can be as important as the information itself in shaping the dynamics of engagement (Klain *et al.*, 2017).

Careful consideration is needed as to the forms of any community benefits offered as part of the energy project. The types of benefit made available are likely to vary between locations but flexible and transparent processes, with active negotiation with local representatives on their design and distribution, can help to address perceived imbalances between the impacts and benefits of projects. Benefits can include community funds, community ownership, apprenticeships and studentships, educational programmes, and electricity discounts, while indirect benefits, such as enhanced tourism, should also be discussed (Firestone, Kempton and Krueger, 2009; Rudolph, Haggett and Aitken, 2014, 2017). Energy projects can also bring community benefits in their own right, e.g. by lowering energy costs and/or improving reliability of connections, though it should not be assumed that these alone are sufficient. A recurring theme in work on community benefits is that benefit schemes should be tailored to the needs of individual areas, sites and projects (Rudolph, Haggett and Aitken, 2017). For example, Devine-Wright and Sherry-Brennan's (2019) analysis of a community benefit fund for a high-voltage power line in Ireland highlights the need for iterative dialogue with local stakeholders when determining the boundaries of benefit schemes. Negotiated approaches were seen as preferable to more formulaic approaches to 'boundary drawing' in securing acceptance that eligibility for benefits had been determined fairly and reflected local knowledge and interests.

3.2 Assessing energy demand outlook and identifying options

A key determinant of decisions about the future of an isolated or peripheral electricity system is an informed view of demand for electricity, the factors that drive changes in demand, and how these may evolve over time. The first stage in a demand assessment is the gathering of appropriate information. Secondly, consideration needs to be given to how changes in consumers' behaviour can impact energy demand.

3.2.1 Overview of key principles of GM

The GM therefore considers:

- Aggregate demand data across electricity, heat and transport
- Historical demand by sector and geography
- Granular data on domestic energy usage patterns
- Economic and demographic drivers of energy demand
- The interaction of policy and behaviour change, particularly with regard to increasing levels of energy 'prosumption'
- Anticipated changes to energy demand or production

3.2.2 Current Energy Demand Assessment

According to the data from Western Power Distribution (WPD) (Larkins, 2020), the total power demand for all islands is shown in Figure 4 for the entire 2019. The total energy consumption on the IoS is approximately 18.732GWh and the average power demand for a year is 2.14MW. The maximum recorded power demand is 4.92MW and occurred at around 7 pm in mid-April. On a typical day there is a peak power demand during the day from 6 pm to 7 pm, as shown in Figure 5. Despite the IoS being connected to the UK national grid, there were seven total power blackouts of at least 30 minutes during 2019, as shown in Figure 6 (April, July, August, September and October). This was due to the faults on the island's grid cable (Larkins, 2020).

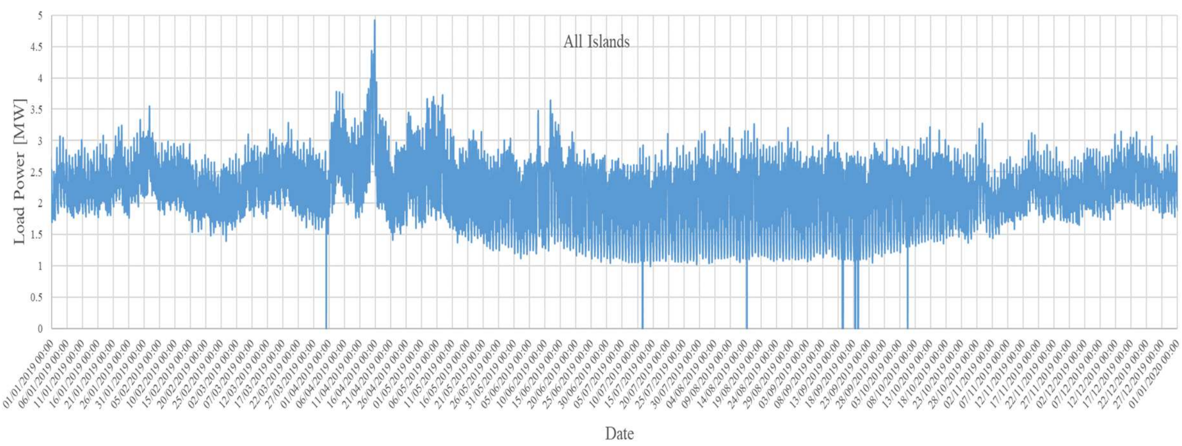

Figure 4 - Total power demand for all islands through 2019

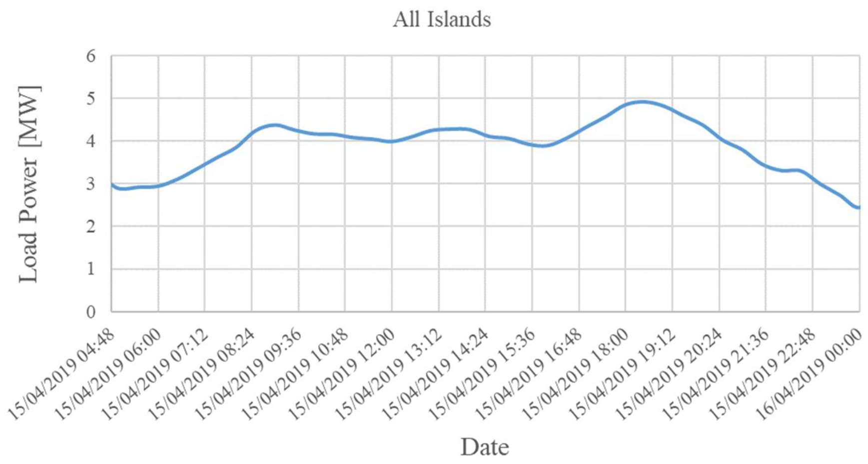

Figure 5 – Load profile for the 15th April 2019, the day with the highest demand load in the data.

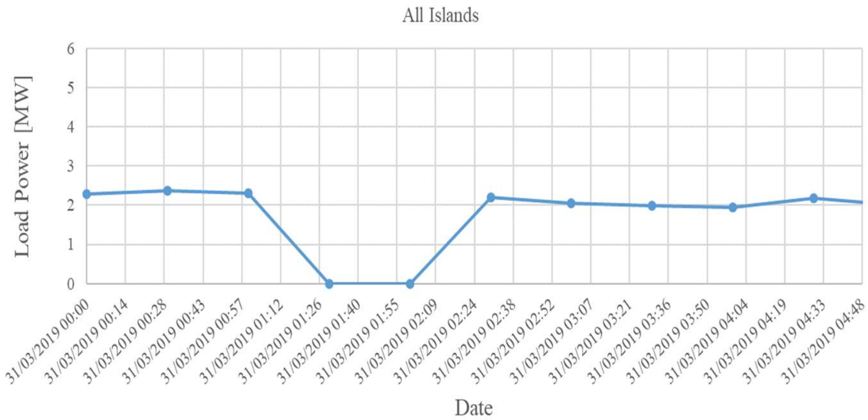

Figure 6 - Power total blackout (2019)

The total annual energy consumption on the IoS is approximately 18.732GWh per annum. The average power demand for a year is 2.14MW. The number of connected customers and the population, shown in Table 2 and

Table 3, are distributed similarly across the islands. The power demand for each island can be calculated based on the population of each island.

Table 2 - Number of customers for each island

Island	Number of Connected customers	Percentage
St Mary's	1314	78.31%
Tresco	132	7.87%
St Martin's	110	6.56%
Bryher	63	3.75%

St Agnes	59	3.52%
Total	1678	

Table 3 - Number of people for each island

Island	Number of people	
St Mary's	1700	77.98%
Tresco	175	8.03%
St Martin's	135	6.19%
Bryher	170	4.04%
St Agnes		3.76%
Total	2200	

The next steps are to find the load at each node and do power follow and reliability assessment. All these steps will be shown in the next sections.

3.2.3 Potential future changes to energy demand.

Reduced demand

The IoS Council have a target to reduce energy bills by 40% by 2025 through reducing energy consumption and lower energy prices. Efforts to improve building heating efficiency are already underway from the IoS Council and the Duchy Estate. Installing insulation measures as well as more efficient heating technologies (e.g. heat pumps) are both ways to reduce the demand for energy for heat. The use of more efficient electricity devices (e.g. light bulbs and appliances) will directly reduce electricity consumption. The widespread deployment of heat pumps across the IoS could have a transformative effect on the isles' energy consumption but this is beyond the scope of this analysis. In this study, the future energy scenarios will assess the potential savings from domestic insulation measures.

Smart technologies

The increasing deployment of smart technologies for storing energy and flexing electricity demand will help alter the energy load profile to match variable generation. This will enable the community to make maximum use of the cheaper renewable energy. There are plans to install a small number of domestic battery systems on the IoS. Our modelling of future energy scenarions will determine an optimal storage capacity for the IoS.

3.3 Energy supply outlook

Developing an understanding of the current and future potential of available energy sources is a key step in the ICE Methodology.

3.3.1 Overview of key principles of GM taken from ICE report T2.1.2

There are two main components to this activity:

1. *Evaluating current energy supply:* A comprehensive review of the current energy supply options with its related infrastructures, attributes and options is a good first step in gauging the supply options for the system
2. *Assessing renewable energy potential*: Once the initial data on the current supply options is assessed, the current and potential supply options must be evaluated to gain insights into which of the supply option can be useful. The choice of supply option is intertwined into the stakeholder goals and objectives for the type of energy system pursued. Resource assessments carried out for the renewable generation technologies can provide a basis for their use as a supply option. This enables the quantification of the amount of energy available at a site or sites and to estimate the amount of electricity or heat that is be extracted. Included in the resource quantification can be the estimated power that could be exported to the local grid as a unit commitment with the demand. An assessment of the correlation of generation times with consumption is also needed. Consideration of the technical, environmental and social constraints to deploying the potential technologies should be included.

3.3.2 Current Energy Supply

Electricity

Most electricity consumed on the IoS is transmitted from the mainland via the subsea interconnection. As we do not have access to production data for the 457 kWp of solar PV installed on the islands, we estimate that it could generate around 485,791 kWh/year, assuming it is all South-facing and mounted at a 30^{o} angle, which represents 2.6% of the 18,500 MWh/year demand. Due to the heavy reliance on the mainland grid for electricity, the energy mix on the IoS can be assumed to be broadly equivalent to the National Grid mix.

The reliance on the mainland interconnector cable is a security issue. Increasing renewable generation on the islands is one way to reduce the risk, costs and potential impacts of cable failure.

Heat

We analysed EPC data from the IoS, available for 657 domestic properties (as of 29th May 2020), to produce a picture of the islands' heat system. Heating on the IoS is generated by a mixture of fuels as shown in Figure 7. Electricity is the dominant fuel, providing more than two-thirds of homes' heating (69%), followed by oil (13%) and coal (8%). Given that Renewable Heat Incentive payments are based on the EPC certificate post-installation, it is likely that the 22 air-source heat pumps and 2 ground-source heat pumps in the EPC database represent close to all of the heat pumps so far installed on the islands.

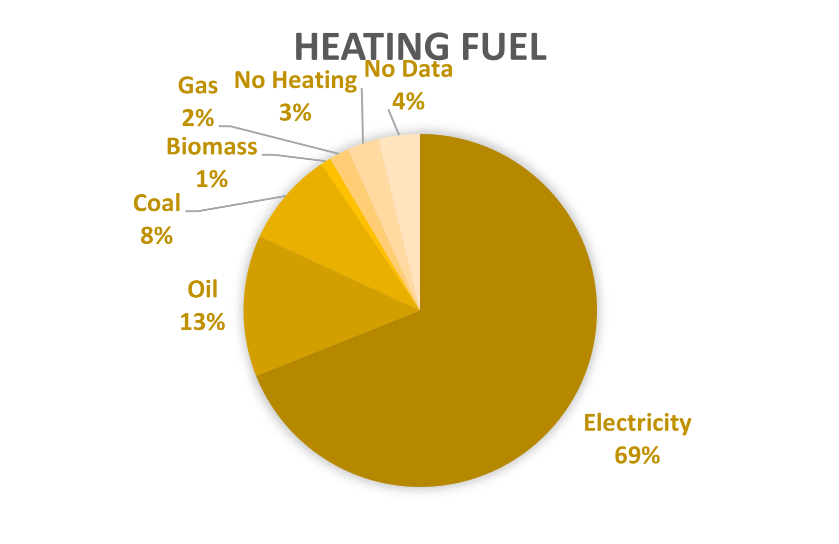

Figure 7 - Proportions of heating by source fuel on the IoS

With regard to energy efficiency, the EPC data in Figure 8 shows that the roofs were relatively well-insulated though a substantial amount (17%) remain 'very poorly' insulated, windows were average for the UK and wall insulation levels were mixed with a third (33%) achieving 'good' or 'very good' whilst almost half (49%) remain 'poor' or 'very poor'.

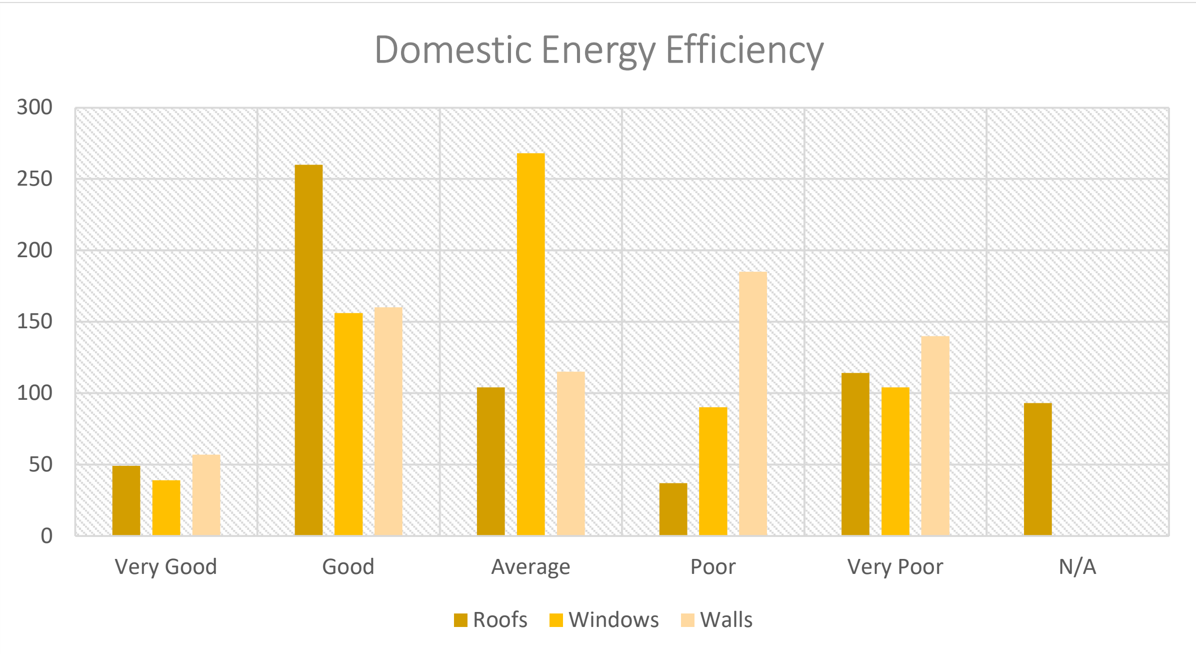

Figure 8 - Building fabric energy efficiency on the IoS

Transport

Transport on the IoS was not analysed in this study. There are an estimated 1500 cars on the IoS, but the geography of the islands means journey distance is low. The shift to EVs may offer some potential for future consideration of storage potential to support grid management.

3.3.3 Renewable Energy Potential

Solar Resource Assessment

Solar PV is one of the most cost-effective technologies to generate electricity in the UK (BEIS, 2020). The map in the appendix shows solar irradiation across the UK and indicates that the Isles of Scilly have a relatively high potential for solar PV deployment.

Resource Constraints

The available solar resource on the IoS has been estimated through PVGIS, using average values from 2012-2016 in the database PVGIS-SARAH. PVGIS uses combined satellite data to estimate the irradiance received at a location at a spatial resolution of roughly 6km squares.

PVGIS-SARAH provides average monthly and hourly data for the island, the specific latitude and longitude used were 49.914° - 6.294°, respectively. The latitude and longitude identify the location of the island's airport, situated in the most densely populated area on the island. The 6km spatial resolution of this software is large enough so that any variance in solar radiation around the island will be minimal.

3.4 The direct normal irradiation (DNI) received is expected to be 1062 KWh/m^2/year, the global horizontal irradiation (GHI) is 1145 KWh/m^2/year and on a plane of 37° 1326 KWh/m^2/year. The values are presented below in Solar PV on the IoS

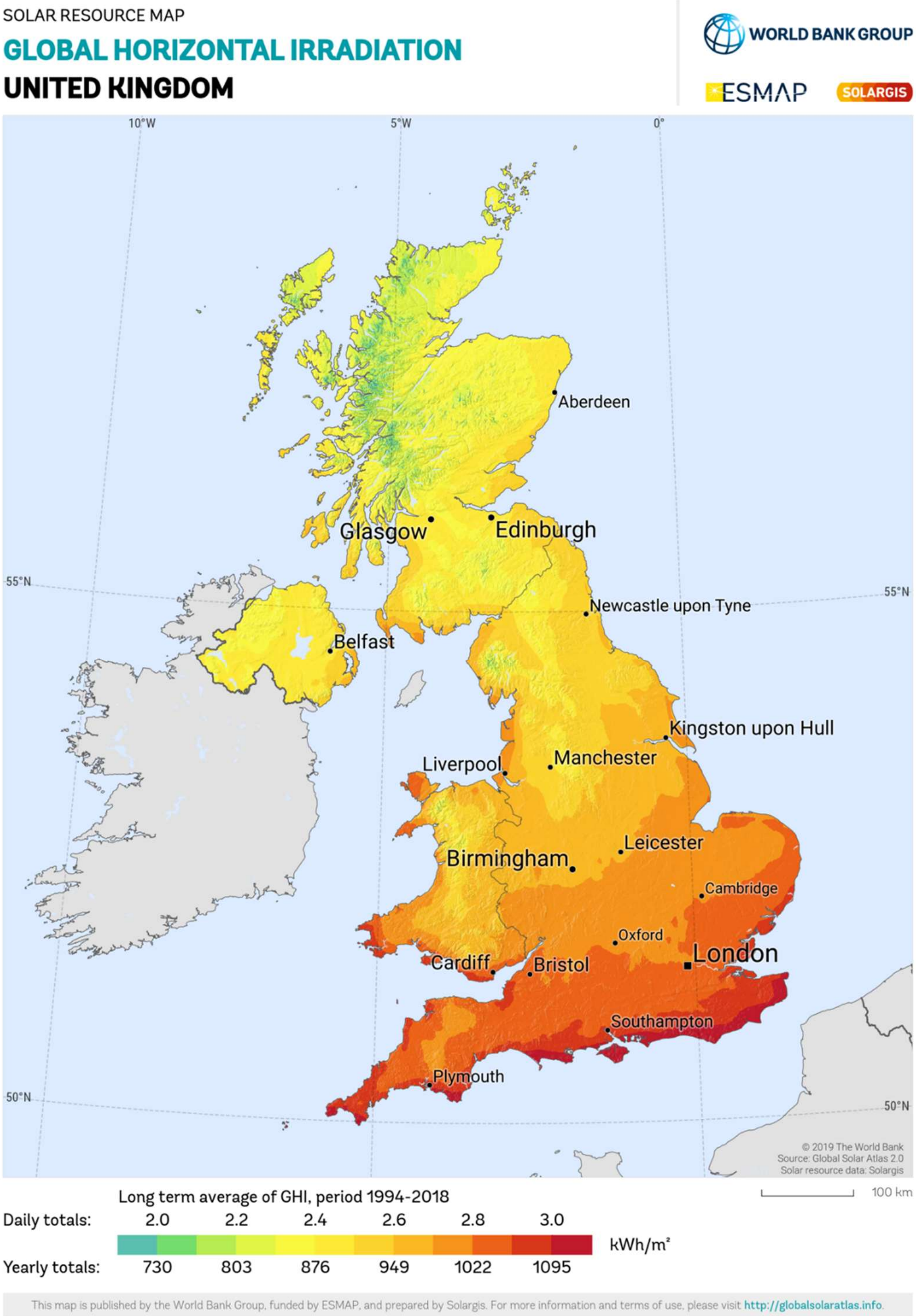

Figure 21 - Solar Geographical Information System Image of the UK

Table 11**Error! Reference source not found.** and graphically presented in Figure 9. **Error! Reference source not found.**The optimum tilt angle for the PV panels is estimated at 37° facing due south.

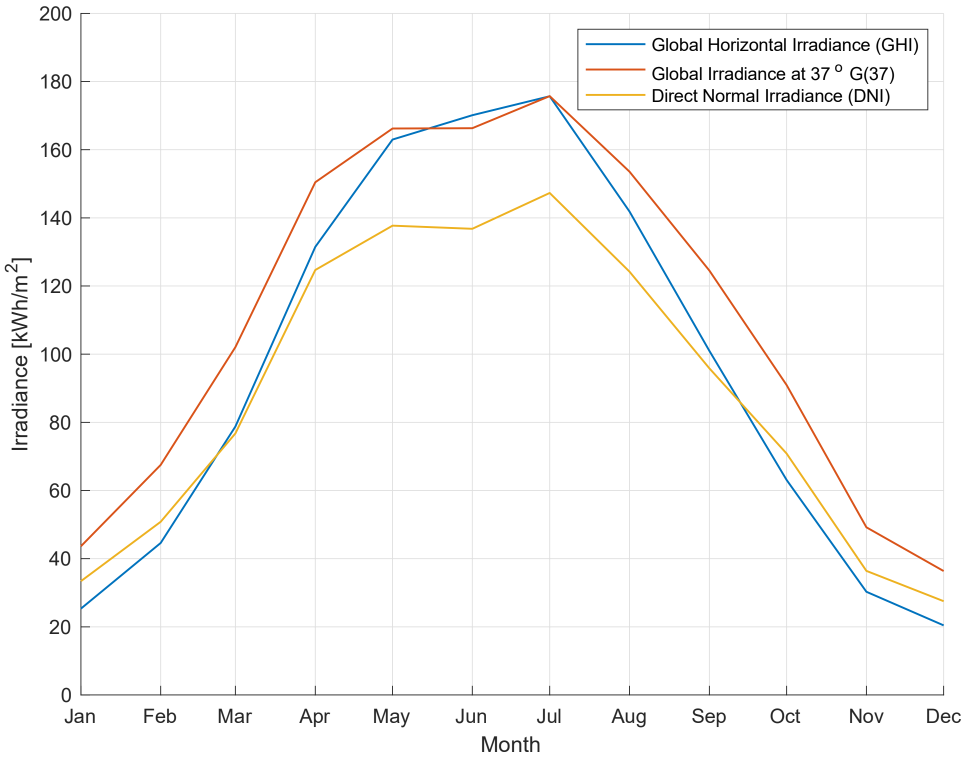

Figure 9 - Global and direct normal irradiance for Isles of Scilly from PVGIS (averaged over years 2012-2016).

The latitude of the Isles of Scilly results in high seasonal variability in solar irradiance. The reduced daylight hours in winter coincides with lower irradiance intensity meaning that the solar resource is much lower in winter than in summer. Additional tables and data can be found in Appendix 1.

Technical Constraints

Rooftop solar PV panels have been deployed widely across the UK and can be installed on the roofs of most buildings. To generate the most electricity, the panels should be located on a south-facing, sloped roof. Panels facing East and West are also viable and mounting systems for flat roofs are also available. Typically, in the UK output of less than 3.68KW does not need any permission (Energy Networks Association, 2020).

Equipment used in typical solar installations is not especially large or complex and even the more specialised elements are readily available on the UK mainland, if not on the IoS. There are numerous solar installers located in Cornwall who could travel to the IoS with equipment via the ferry without special transport requirements.

Independent solar farms may be installed away from existing grid connections, however, in this case a connection to the network will also need to be constructed. The installation route and methodology should be taken into account when planning a project. Proximity to existing infrastructure will be a key factor is deciding where to site a project.

Environmental social and political constraints

In the UK the installation of rooftop solar panels is deemed a permitted development, not requiring planning permission unless a building is listed or in a conservation area (The Renewable Energy Hub, 2020). National guidance states that the panels must:

- Not to be installed above the highest point of the property.
- Be installed as to minimise visual impact.
- Not protrude at a distance greater than 200mm from the surface of the roof.

The IoS islands as a whole are an Area of Outstanding Natural Beauty. The isles also contain Sites of Special Scientific Interest (SSSI), and special areas of conservation. The IoS also have several areas designated as scheduled monuments. There are at least 130 grade I and II listed buildings on the Isles of Scilly (British Listed Buildings, no date). These designations and more information can be found in Appendix 1.

Local planning policy is generally supportive of renewable energy generation where the visual and environmental impacts are minimised (See Appendix 1). There is existing roof-mounted and ground-mounted solar PV installed on the IoS. Recent developments on the island have seen panels installed on a selection of properties.

In addition to avoiding protected environments, scheduled monuments and listed buildings in our modelling, a number of other constraints were included when identifying potentially viable sites for ground-mounted solar PV:

- Excluding registered parks and gardens
- Excluding golf courses
- A 10 metre buffer around buildings and built-up areas
- A 10 metre buffer around woodland
- A 5 metre buffer around hedges
- A 5 metre buffer around heath and shrubland
- A 10 metre buffer around roads

Site Selection and Power Production

Accounting for the above restrictions, a large area of the islands is available in principle for ground-mounted solar. Figure 10 shows areas of St Mary's wih the potential for siting panels. However, a number of factors are excluded from consideration here including: shading from trees, visual impacts, consultation with property owners or neighbours, distance from listed buildings, access to land.

Figure 10 - Potential sites for ground-mounted solar on St Mary's are shown by the yellow areas. Image from QGIS analysis.

The QGIS analysis was repeated across all five islands. For ground-mounted solar we modelled the production from 300 Wp panels in standard test conditions, assuming a 34^{o} inclination and a 6.6m spacing between rows to optimise performance and minimise shading. Our modelling indicates that this will generate 1,027 kWh per kWp installed annually.

For potential roof-mounted solar PV sites, we estimate that there are 1,182 domestic rooftops and we identified 54 warehouses and barns with roofs potentially suitable for solar PV. Based on the available sites and general characteristics, we developed hourly energy production estimates for a range of representative system types on different sites which are summarised in Table 4 – more information can be found in Appendix 1.

Table 4 - Solar Data from PVsyst for each system type

Location	Installed Power	Orientation	Degrees	Annual Energy Production (kWh)
Dwelling Roof	3kWp	South	30	3190
Dwelling Roof	3kWp	East	30	2533
Dwelling Roof	3kWp	West	30	2648
Dwelling Roof	3kWp	East	10	2694
Dwelling Roof	3kWp	West	10	2725
Barn Roof	12kWp	South	10	12375

Barn Roof	12kWp	East	10	11466
Barn Roof	12kWp	West	10	11611

Wind Resource Assessment

Wind turbines are the leading renewable electricity generation technology in the UK, producing 20% of the UK's electrical power in Q3 2019 as well as being one of the most cost-effective technologies for generating electricity in the UK (BEIS, 2020). Figure 29 shows the distribution of wind speed around the UK and indicates that the Isles of Scilly have a strong potential for wind turbine deployment.

Resource Constraint

The wind data was obtained from NOAA, recorded at the weather station at St Mary's airport (ICAO = EGHE), 31 metres above ground level at latitude 49.9170, longitude -6.3000. Five years of data were used from 2013-2017 to derive mean figures which we scaled to specific turbine heights. To map the distribution of wind speeds over various heights, a histogram shown in Figure 11 was produced for the recorded wind velocities at 8m. The distribution shows that the data fits to both a Rayleigh and Weibull curve. More information is available in Appendix 1.

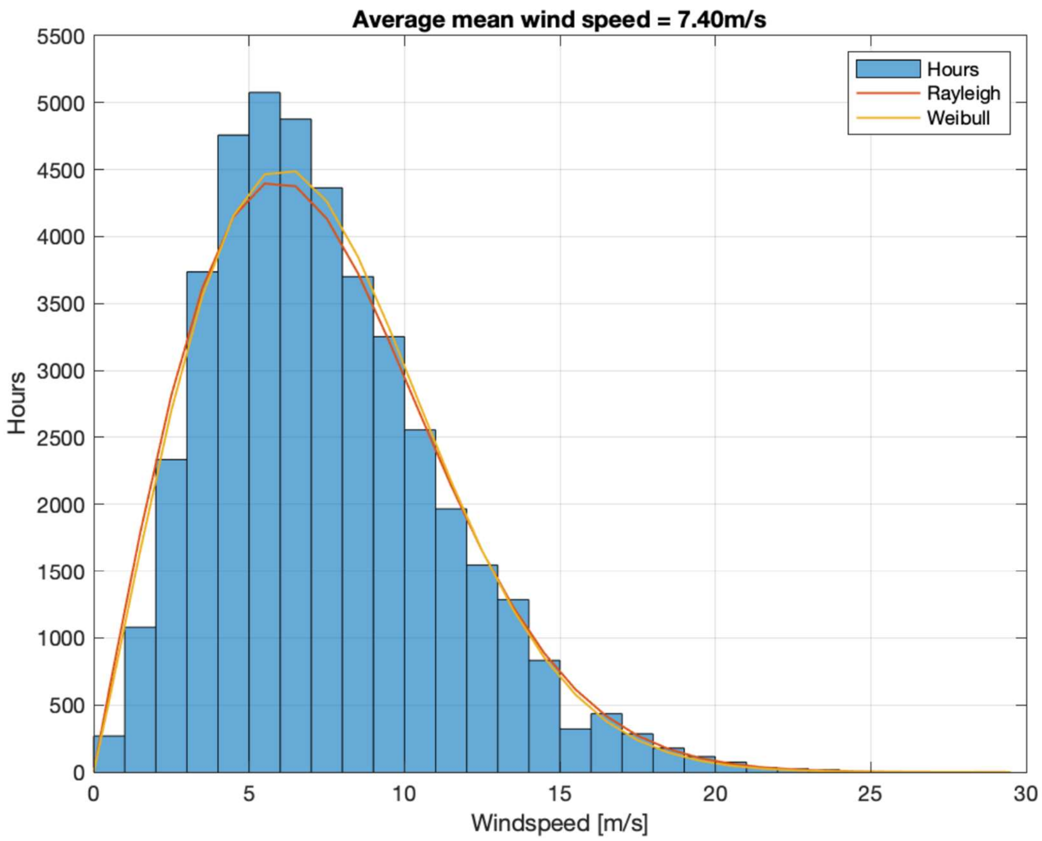

Figure 11 - Hourly wind speed distribution at 31m above ground level from NOAA over 5 years. Rayleigh and Weibull curves fit to the data.

Technical constraints

Technical constraints on the installation of one or more wind turbines on the IoS include requirements for a site accessible to large construction vehicles, suitable terrain and connection to the local electricity network. Delivery of the turbines and specialist construction equipment will also need to be planned for.

A granite bedrock underlies the majority of the IoS covered by a thin layer of soil and vegetation (See Appendix 1 for more detail). Where there is bedrock close to the surface drilled piles or gravity bases can be used (Ashlock and Schaefer, 2010). As we were unable to travel to the IoS during this study, we limited the viable sites to those identified in the IoS Energy Infrastructure Plan (Hitachi Europe Ltd, 2016).

The route and distance of any high voltage and low voltage cabling will contribute to the cost and complexity of the installation. It will be necessary to ensure that the cables and components are of sufficient capacity to export the maximum power from the turbine(s).

Environmental social and political constraints

There are several environmental impacts and safety constraints to consider when siting a wind turbine. These would be evaluated and mitigated through the planning process, and we detail these considerations in Appendix 1. Whilst overall, local planning policy emphasises the visual impact of a wind turbine on the landscape meaning that opportunities are "likely to be limited" (Council of the Isles of Scilly, 2016, p. 68), we note that the IoS Energy Infrastructure Plan (Hitachi Europe Ltd, 2016) does highlight a number of potentially viable sites (Figure 12). In this study we assume that one or more of these would be used were a turbine to be installed.

Figure 12 - Potential wind turbine sites (Hitachi Europe Ltd, 2016, p. 42)

Power production

In this study we have examined the power production of a 100 kW (the nED100) and a 250 kW (Vergnet GEV MP C) wind turbines. Both turbines have a height below 50 metres, lower than larger turbines, and installing multiple turbines allows generation to be scaled appropriately. The power curves of the two models are shown in Figure 13.

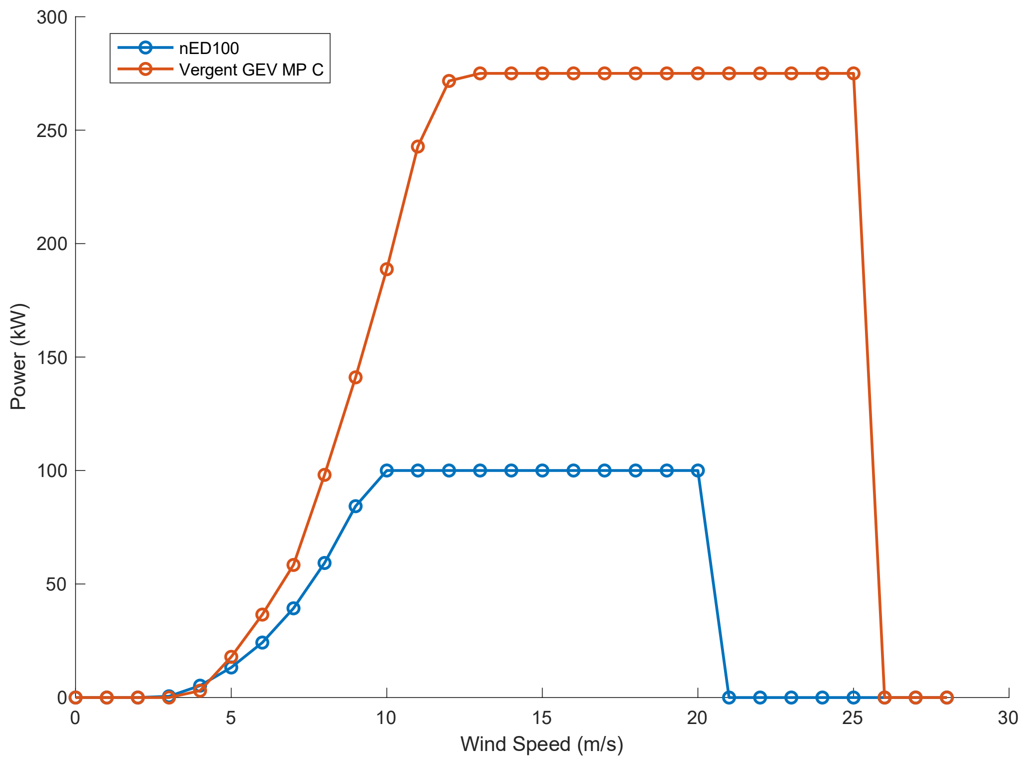

Figure 13 - Power curves of the nED 100 (100kW turbine) and the Vergnet GEV MP C (250kW turbine).

The two turbine models produce different generation profiles over the year, as summarised in Table 5.

Table 5 - Seasonal varation in wind generation and demand

Turbine	Summer Generation (MWh)	Winter Generation (MWh)	Ratio Summer: Winter	Demand Ratio Summer: Winter
nED 100	264	250	51.4 : 48.6	47.9 : 52.1
GEV MP C	520	536	49.2 : 50.8	

Sources: (Norvento, 2015; Wind Turbine Models, 2020)

3.5 System reliability assessment

The ICE Methodology recommends rigorous reliability analysis of the electrical system to determine the envelope for action.

3.5.1 Overview of key principles of GM taken from T2.1.2

The main purpose of the reliability study is to establish the reliability of the current energy system to then assess the impact different generation/storage/smart energy options may have on the system reliability in the future. Parameters that will be used for this analysis include:

- Reliabilities of energy security and availability
- Target reliability/availability
- Potential for optimised supply and generation mix.

The analysis rests on two distinct studies:

1. *Reliability study of the network:* This is done by translating the physical electrical distribution network into a conceptual Reliability Block Diagram (RBD). Some software to facilitate this process and the subsequent analysis readily exists, e.g., ReliaSoft. The primary objectives of the reliability analysis are to obtain a life distribution that describes the times-to-failure of a component, subassembly, assembly or system. This analysis is based on the time of successful operation or time-to-failure data of the item (component);
2. *Power Flow Analysis:* In order to understand the power flow in the network. This is derived through a power flow analysis, analysing the voltage levels for each load node. Software such as Matlab Simulink will be employed for the power flow analysis;
3. *Options for smart system operation and innovative technologies:* Once the reliability and power flow of the current system is established, the information will be used to model and assess the different generation and supply portfolios. This will incorporate the renewable energy generation and the correct physical locations, i.e., connect to the correct geographical network nodes. Both types of analysis, the reliability study of the network and the power flow analysis, will be carried out for the range of generation/smart technology scenarios.

Accurate data on the following is a prerequisite for the most rigorous analysis:

A. Schematic diagram of the island power-system network and the network voltage.
B. The main components of the island network, such as power cables, transformers, circuit breakers and generator units.
C. Failure rate of the main components of the network or a record of the failure for each network components for 5 years or more.
D. The cables type, length and size.
E. The transformer parameters, terminals voltage, parameters and type.
F. The electrical generator parameters (power, type and impedance).
G. The load (active and reactive power) at each load connection node for a year at least in hourly time intervals.
H. The circuit breaker information, location and type.

However, data collection has proven to be a challenging issue in some contexts. The ICE methodology document T2.1.2 outlines some of the considerations for accessing suitable data (Matthew *et al.*, 2018).

3.5.2 Power Flow and Reliability Assessment Summary

IoS consists of five islands where St Mary's is the biggest island and it is the only power connection point to the Cornwall mainland. The maximum power demand is 4.92MW. Table 6**Error! Reference source not found.** summarises all the results for the power flow and reliability assessment for the four islands. St Martin's has the highest voltage drops (2.06%), cable capacity (19.34%) and failure rate (0.2442/year). This because it supplies a part of Tresco Island and it has only one supply feeder from St Martin's, at the worst scenario. Tresco has the highest power demand, 3951 kW. The lowest voltage drops and able capacity are in Bryher.

Table 6 - Power flow and reliability assessments

Island	Load node						
	Total Power [10]	Voltage drop[kV]		Cable capacity [%]		Failure rate per year	
		Max	Min	Max	Min	Max	Min
Bryher	198.78	0.17%	0.15%	7.76%	0.34%	0.2436	0.2254
St Agnes	185	0.39%	0.35%	7.12%	1.2%	0.2385	0.2111
St Martin's	322.8	1.06%	0.87%	19.34%	2.67%	0.2442	0.1337
Tresco	395.1	0.88%	0.21%	17.96%	0.62%	0.14131	0.09287

The detailed workings behind this can be found in Appendix 1.

3.6 Scenario analysis

Uncertainty about the future is an inherent component of decision making in energy systems. The many different possible futures, each with different social, technical, economic and political characteristics. Which future we arrive at is decided by innumerable decisions and events along the way (Schwartz, 1997), many of which will be beyond the control of individual stakeholders.

3.6.1 Overview of key principles of GM taken from T2.1.2

The ICE Methodology suggests the use of scenario analysis to make decisions about how best to:

- test or examine different plans and policy options, with the aim of exploring which combinations are likely to work more or less well in which scenario(s);
- provide the basis for developing new policies or actions;
- provide the basis of a strategic vision about an organisation's evolving role or opportunity; and
- act as a means of identifying signs of movement towards a particular kind of future

Scenario analysis can use both qualitative quantitative techniques to develop narratives/storylines that describe scenarios which describe how the world might look at some stage in the future. A set of different scenarios is often developed to reflect the range of different possible futures that might take place. In order to be useful, each scenario must be plausible, internally consistent, based on rigorous analysis and engaging (Foresight 2009). These different futures are shaped by different actions, trends and events. The ICE methodology advocates the use of scenarios across the scope of the transition. The scenarios can be developed from the outlook of the demand and supply options and will give insights into the preferred plan/s that will signal the smart energy transition of peripheral communities.

The figure below outlines the general scenario analysis process:

Figure 14 Scenario development process

3.6.2 The Scenarios on the Isles of Scilly

We developed two sets of scenarios for the IoS, aiming to provide 40% of electricity demand from renewable generation. The IoS also have an ambition to reduce electricity bills by 40% by 2025 through energy efficiency and utilising renewable generation. We used Energy Perfomance Certificates to estimate a potential 9.92% saving through domestic energy efficiency on the IoS and applied these savings to the electricity demand in all scenarios. The first set examines the potential of solar PV generation with and without battery storage. The second set combines solar PV and wind generation along with battery storage. The scenarios are summarised in Table 7. All scenarios are modelled using hourly generation and demand data over a year.

Table 7 - Scenarios on the Isles of Scilly

Scenario	Description	% Renewable Energy
1.1	1.92 MW Solar PV generation	11%
2.1	1.92 MW Solar PV & 1.5 MW wind generation	41%
2.2	3.36 MW Solar PV & 1 MW wind generation	40%

Estimating potential energy efficiency savings

We analysed Energy Perfomance Certificates (EPCs) from the IoS as a tool to develop an understanding of potential heating energy efficiency savings from domestic properties. There were domestic EPCs available for 657 separate properties on the island (48%). Given that newer and renovated properties are more likely to have an EPC assumptions from these data probably represent an above average sample in terms of energy efficiency, meaning that our conclusions are unlikely to overstate potential savings. Our calculations indicate that applying cavity wall, loft, and solid wall insulation to all properties for which they are appropriate and which do not currently have them installed would cut heating energy by 18% overall, totalling 1,849 MWh annually. For more detail, please see Appendix 1.

This energy saving is incorporated into our scenarios as a reduction in annual demand. As we do not have accurate energy demand data broken down by end use, we reduced every hourly demand reading by the same percentage.

Scenario 1

The first scenario is designed to demonstrate a modestly ambitious level of solar PV deployment; due to the divided local opinion on wind turbines, no wind generation is included. This allows consideration of the potential without wind, should this prvoe to be unacceptable to the community. The rooftop solar PV deployment represents roughly triple the current installed capacity, along with a ground-mounted solar farm. Scenario 1.1 assesses the electricity generated from 1,440 kW of rooftop solar PV (roughly 1 MW more than current levels of deployment) and 480 kW of ground-mounted solar PV. The rooftop solar PV is assumed to comprise 279 domestic pitched roofs and 21 domestic flat roofs (22% of domestic properties), as well as 30 non-domestic barns and warehouse buildings half of which face South and half East-West. The ground-mounted solar PV is located close to St Mary's airport in an area which already has solar PV in its vicinity; Figure 15 shows areas potentially viable for solar PV and Figure 16 shows the area and layout selected for the purpose of this scenario. This results in 900 kW on domestic properties and 540 kW on non-domestic buildings. Over the year, 1,971 MWh are generated and injected into the grid providing 10.57% of energy demand. The peak deficit is in early April when demand on the grid peaks. This is likely due to the Easter holidays bringing visitors to the

IoS at a time when energy-intensive space heating (largely electric) is still in use whilst the solar PV is not generating at full capacity. Table 8 summarises scenario 1.1 and Figure 17 shows demand and solar generation modelled over a year.

Figure 15 - Potential ground-mounted solar sites by St Mary's airport shown by the yellow shading. The current solar garden is to the north-west of the airport.

Figure 16 - The three segments shown use area that was deemed appropriate by GIS analysis, and provides adequate land space for the 480kW solar. From left to right the segment areas are 1265.7m^2, 3783.6m^2 and 6313.2m^2, totalling 11,362.5m^2 of land. The 1,600 solar PV modules are angled at 34 degrees and the module pitch length (row spacing) is 6.6m.

Table 8 - Summary of scenario 1.1

Scenario 1	**Annual**	**Summer (Apr - Sep)**	**Winter (Oct - Mar)**
Generation (MWh)	1,971	1,421	550
Demand (MWh)	16,795	8,045 (48%)	8,750 (52%)
Surplus/Deficit (MWh)	-16,670	-7,511	-9,160
Surplus Generation Hours	23	21	2
Deficit Hours	8737	4,359	4,378
Peak Surplus (KW)*		N/A	N/A
Peak Deficit (KW)		4,814	3,510
Usable Energy Generated (MWh -assuming no storage)	1,957	1,407	550

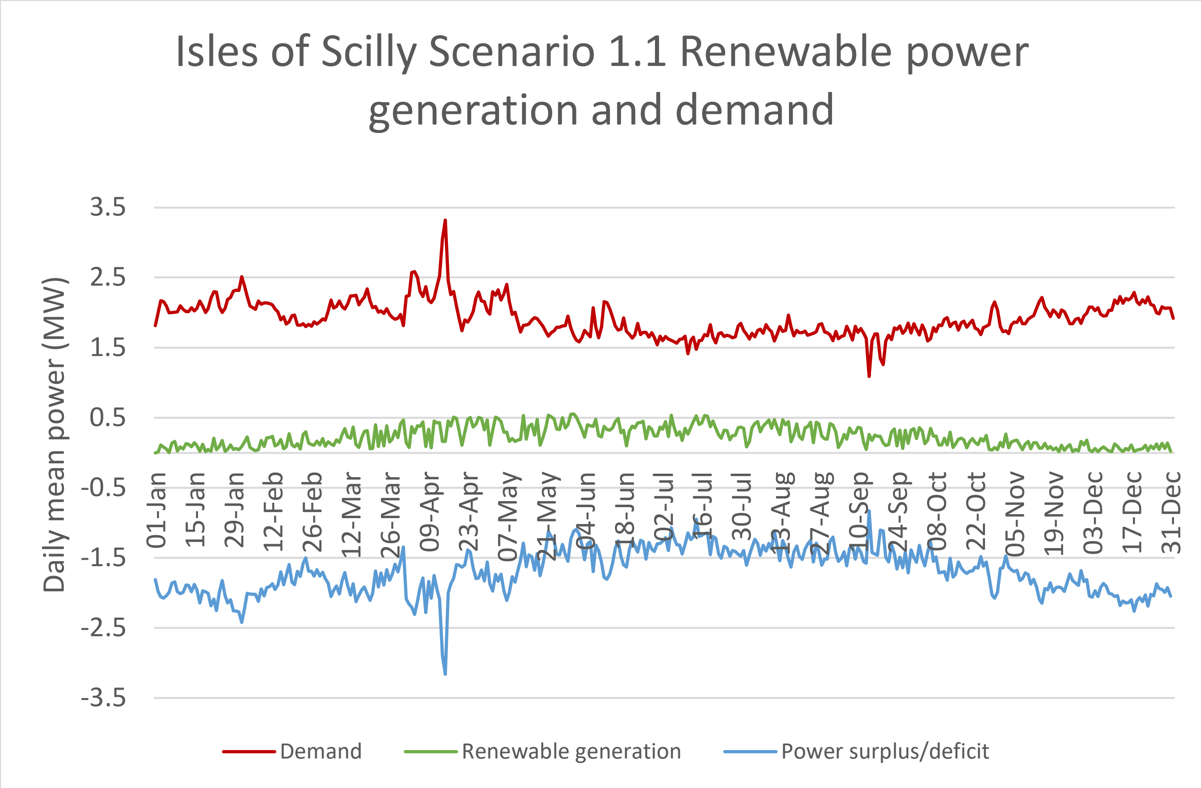

Figure 17 - IoS Scenario 1.1 average daily power surplus/deficit modelled over a year.

This scenario demonstrates that the IoS is likely to be able to absorb the generation from roughly four times the solar PV capacity currently installed. More than 99% of the electricity generated by the 1.92 kW of solar PV capacity is immediately consumed based on our hourly modelling. The generation is strongly weighted towards the summer months, compared to higher levels of energy consumption during the winter and early spring.

Scenario 2.1

This scenario assesses the energy production of the 1.92 MW solar generation capacity specified in scenario 1.1 alongside 1.5 MW wind generation in order to achieve the target of producing 40% of electricity demand from renewables. The wind generation consists of six turbines, each with a capacity of 250 kW, producing 4,902 MWh over a year (29.19% of modelled demand). As in scenario 1.1, the solar PV consists of 1,440 kW mounted on rooftops and 480 kW of mounted on the ground (generating 11.73% of modelled demand). In total, 6,874 MWh are generated and injected into the grid, equivalent to 40.92% of modelled future demand. Table 9 summarises the scenario and Figure 18 shows demand and solar generation modelled over a year.

Table 9 - Summary of scenario 2.1.

Scenario 2.1	Annual	Summer (Apr - Sep)	Winter (Oct - Mar)
Generation (MWh)	6,874	3,108 (45%)	3,766 (55%)
Demand (MWh)	16,795	8,045 (48%)	8,750 (52%)
Surplus/Deficit (MWh)	-9,921	-4,937	4,984

Surplus Generation Hours	711	415	296
Deficit Hours	8,049	3,976	4,073
Peak Surplus (MW)*		1.91	1.45
Peak Deficit (MW)		-4.12	-2.85
Usable Energy Generated (MWh -assuming no storage)	6,586	2,925	3,661

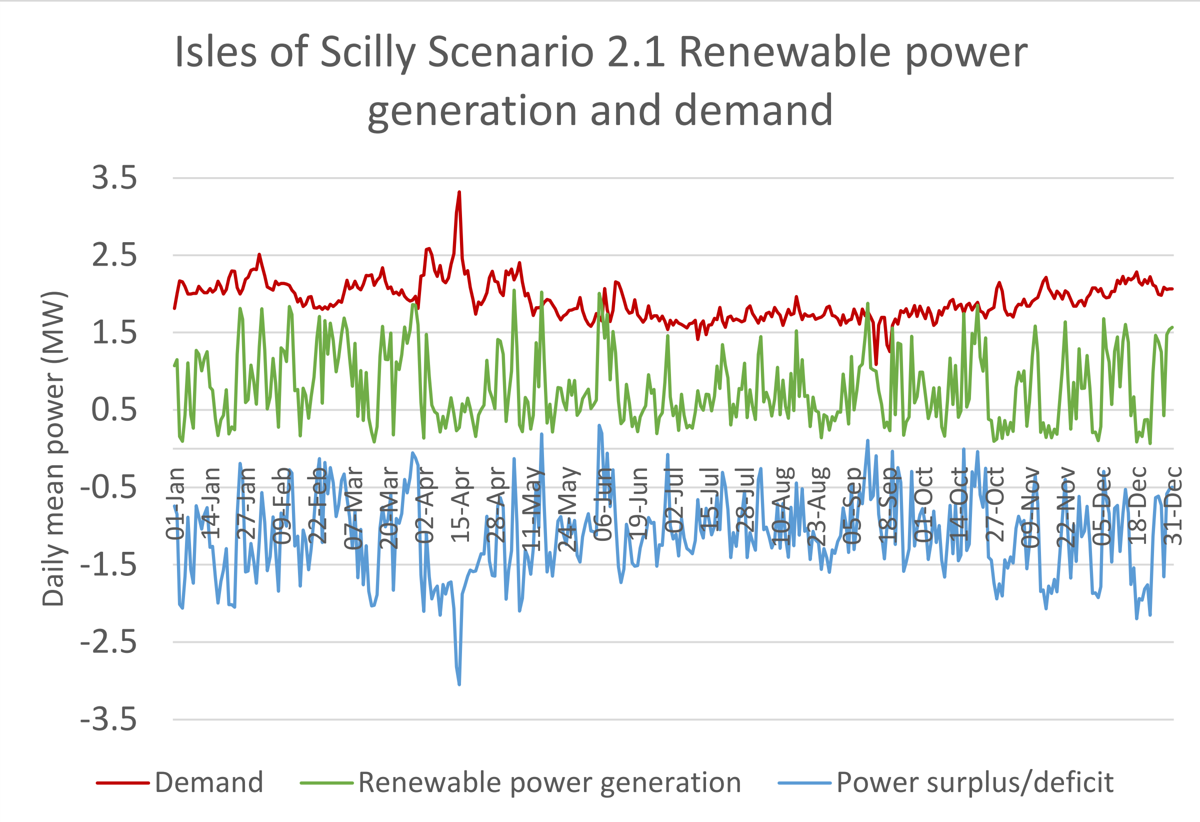

Figure 18 - IoS Scenario 2.1 average daily power surplus/deficit modelled over a year.

The generation profile of this renewable energy capacity is weighted in the same direction as the energy consumption profile on the IoS, with more than half of the energy generated during winter months (55%). This close seasonal match results in an estimated 6,587 MWh of energy (95.8%) being consumed directly without the addition of energy storage. In winter 97% of power generation could be used directly according to the modelling.

Scenario 2.2

Scenario 2.2 limits the wind capacity to 1 MW in order to reduce visual impacts, whilst the solar PV deployment is expanded to compensate for the loss of generation. This scenario examines the performance of an energy system with 1 MW of wind generation and 3.36 MW of solar PV generation which collectively generate 6,718 MWh annually, 40% of modelled future demand. The wind generation includes four turbines rated at 250 kW which contribute just under half of the electricity generation (3,268 MWh, 19.46% of modelled future demand). The solar PV is made up of 1,440 kW mounted on rooftops (as in previous scenarios) with 1,920 kW of ground-mounted modules (four times previous scenarios) located in the vicinity of the airport. Over the year the solar PV generates 3,450 MWh, resulting in 6,718 MWh of total renewable electricity generation on the IoS. Scenario 2.2 is summarised in Table 10 and Figure 19 illustrates daily mean values of the renewable generation and demand model over the year.

Table 10 - Summary of scenario 2.2

Scenario 2.2	**Annual**	**Summer (Apr - Sep)**	**Winter (Oct - Mar)**
Generation (MWh)	6,718	3,587 (53%)	3,132 (47%)
Demand (MWh)	16,795	8,045 (48%)	8,750 (52%)
Surplus/Deficit (MWh)	-10,077	-4,458	-5,619
Surplus Generation Hours	922	666	256
Deficit Hours	7,838	3,725	4,113
Peak Surplus (MW)*		2.72	2.04
Peak Deficit (MW)		-4.19	-2.85
Usable Energy Generated (MWh -assuming no storage)	6,145.4	3,159.8	2,985.7

This scenario generates a similar amount of energy annually compared to scenario 2.1. However, a greater proportion is generated during summer months (53%), and during daylight hours. Currently, more electricity is consumed on the IoS during winter months, partly due to the widespread use of direct electric heating, which means that less of this renewable energy is consumed in real time, with an estimated 6,145 MWh (91.5%) useable without storage.

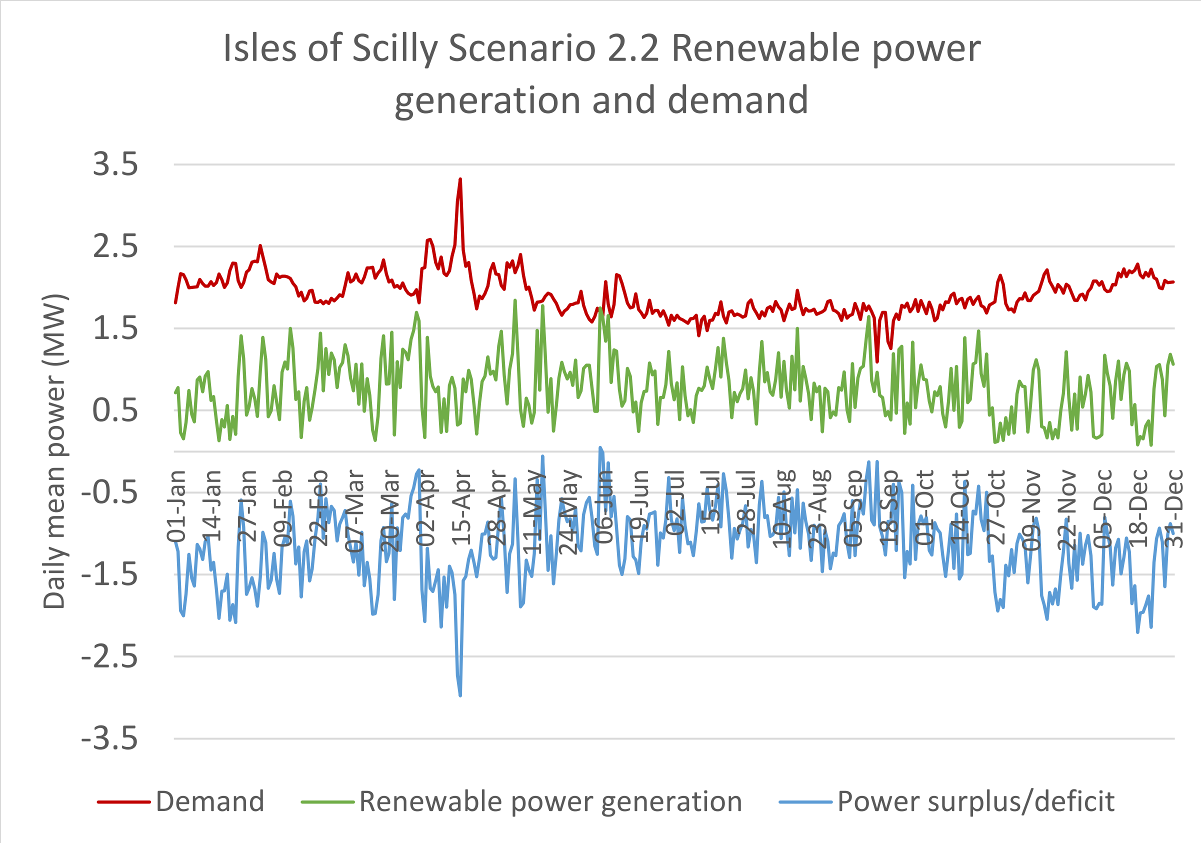

Figure 19 - IoS Scenario 2.2 average daily power surplus/deficit modelled over a year.

3.6.3 Evaluation of the scenarios

Stakeholder evaluation

Usually, the creation of these scenarios would be informed by stakeholder priorities and objectives and these stakeholders would be revisited to understand their views of the modelled scenarios. In this case, it was not possible to carry out a stakeholder evaluation of the scenarios due to time constraints and the global Coronavirus pandemic.

Summary of Load and Reliability Analysis

Based on the guidelines in scenario 2.1, the location of the four WTs can be selected as shown in Figure 30. The nearest connection points of the WT to the island grid are summarised in Table 14.

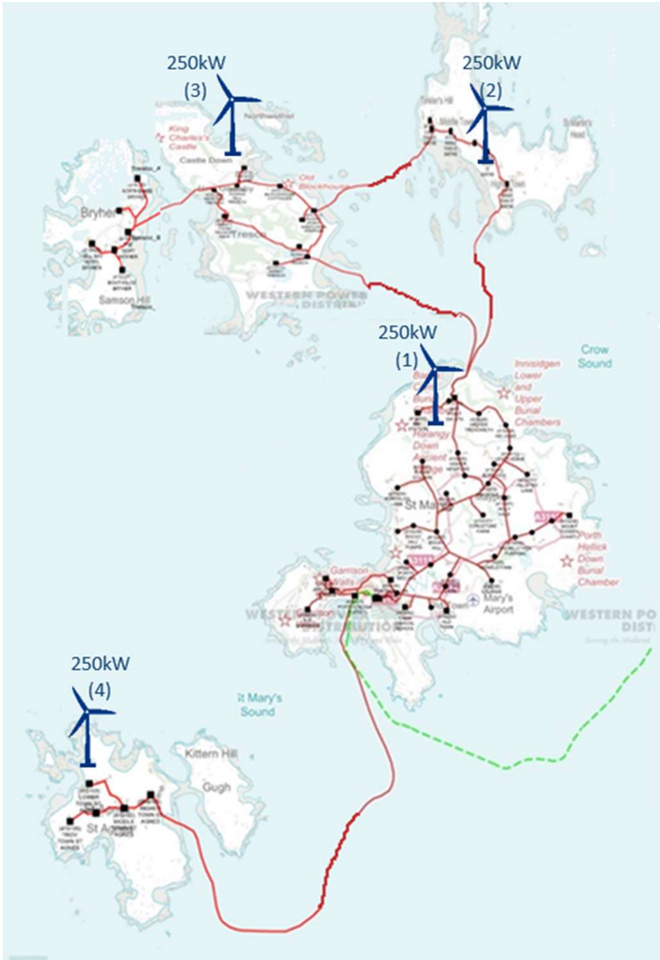

Figure 30 Locations of the WTs for scenario 2.2

Table 14 – WT locations for scenario 2.2

WT	Island	Nearest connection point
1	St Mary’s	5001
2	St Martin’s	5107
3	Tresco	5972
4	St Agnes	5102

Based on the data in Table 14, The voltage drop at maximum load and maximum RE output are shown in Figure 31and Figure 32 respectively.

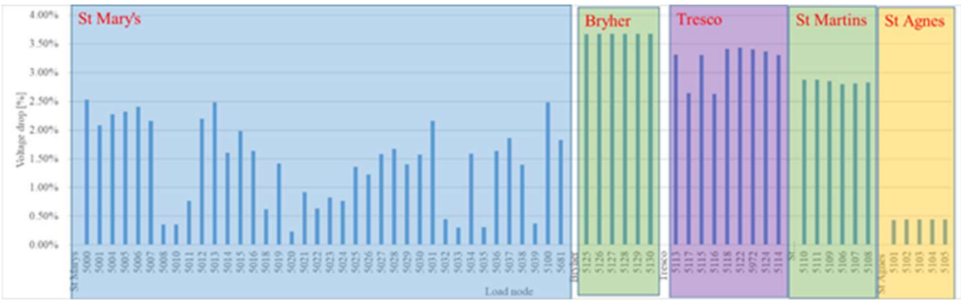

Figure 31 Locations of the WTs for scenario 2.2

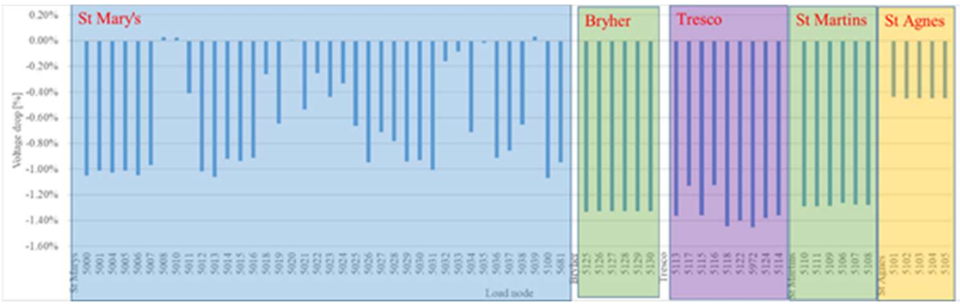

Figure 32 Locations of the WTs for scenario 2.2

The cable usage capacity under the two cases is shown in Figure 33.

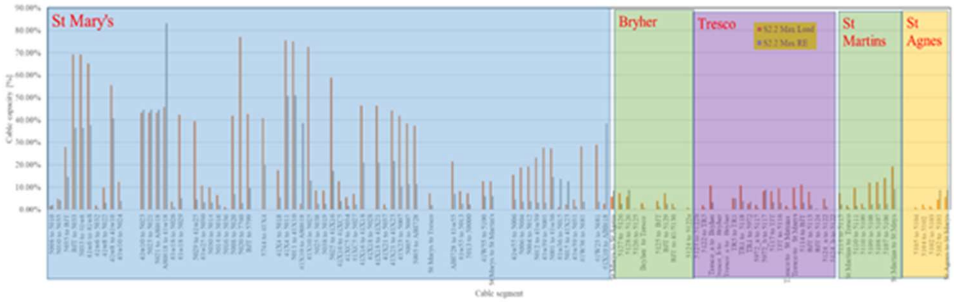

Figure 33 Locations of the WTs for scenario 2.2

For the reliability study, the assumptions in Ushant Island (T1.2) are repeated here. The failure rates of load nodes are shown in Figure 34.

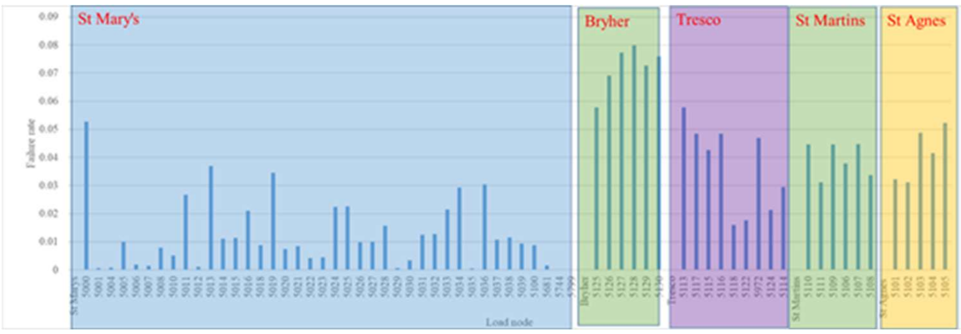

Figure 34 Locations of the WTs for scenario 2.2

A summary of the key data from the power flow and reliability assessments is shown in Table 15. The maximum cable usage capacity is slightly reduced (up to 6%) compared to the utility grid, due to the distribution of the RE sources. Scenario 2.1 is the lowest maximum cable capacity usage due to a large number of the RE sources (six WTs, rooftop PV and mounted PV). The maximum voltage drop is reduced by 14% and scenario 2.1 gives the lowest voltage drop. The maximum failure rate is reduced by 73% in scenario 2.1, the lowest failure rate in our scenarios. Scenario 2.1 thus has the lowest voltage drop, lowest cable capacity usage and lowest failure rate. This is due to a large number of renewable energy sources as mentioned before.

Table 15 - Key data outcome for power flow and reliability assessment for the Isles of Scilly

	Grid	Scenario 1	Scenario 2	
			2.1	2.2
Maximum Cable Capacity (maximum load)	80.23%	76.91%	74.63%	76.92%
Maximum Voltage drop	3.95%	3.78%	3.4%	3.67%
Maximum Failure rate/year	0.2926	0.089	0.078140	0.0799

Battery storage analysis

Each of the scenarios was modelled with a range of sizes of battery storage system from 0.2 MWh up to 20 MWh to explore how storage can increase the consumption of renewable energy, reducing the diesel consumption and carbon emissions whilst increasing energy security.

For the scenarios developed for the Isles of Scilly, we assumed that any surplus renewable generation would be stored locally in the batteries, rather than transmitted back to the mainland, and the analysis found that even with this asumption there was little to no added benefit from storage. This is due to the relatively low penetration of renewables generation (supplying less than half of the islands' power) modelled in the scenarios, as a result the generated electricity is absorbed in real time by the grid. In addition, the fact that the IoS have a grid connection with the mainland must be incorporated into future techno-economic evaluation of the viability of battery storage given that it may be possible to export surpluses back to the UK mainland.

Economic and carbon evaluation

We calculated the levelised cost of electricity (LCOE) for all scenarios on IoS. A description of the data and calculations is available in the Appendix. The analysis revealed that scenario 1 offers the lowest LCOE, but scenario 2.2 has a lower LCOE than 2.1. For all of the scenarios complementing the renewable generation with a battery leads to a small increase the overall LCOE. This higher LCOE grows as the size of the battery increases. Higher costs are to be expected as the IoS have a grid connection which leads to relatively low costs of alternative electricity and fixed generator costs were not included; the fact the increase is small reflects the relatively small cost of storage in a system of this size. On this basis, whilst renewable generation remains a minority fraction of the generation on the IoS it is not clear that large-scale battery storage offers value for money. Residential storage behind the meter was not modelled.

	Scenario 1		Scenario 2.1		Scenario 2.2	
System LCOE (€/MWh) - no storage	€	304.43	€	354.37	€	353.83
System LCOE (€/MWh) - 0.2 MWh	€	304.82	€	354.76	€	354.22

3.7 Implementation challenges

The ICE Methodology recognises that an energy transition is an ongoing process, rather than a discrete event. It is likely that the ideal situation for each island considered within ICE will change over time. Obvious factors which will change are the relative costs of the wind, solar and storage technologies which form the foundation for our scenarios, but the same will also be true for other technologies, such as tidal energy. Improvements in energy efficiency, and the technologies that help deliver it, are also likely to change over time in terms of both cost and usefulness. Smart energy applications are coming to market in increasing volume, and it is likely that one or more of these will have application on some, or potentially all, of the islands in our study. Significant barriers to adoption of these technologies includes:

- overall cost;
- upfront capital expenditure;
- Perception of the usefulness of emerging technologies;
- Sophistication of grid management and the ability to integrate new grid technologies;
- Regulatory barriers, including unforeseen consequences of regulatory architectures developed to meet the needs of centralised generation or mainland rather than island generation.

Attitudes to technology may also change but they may also stay the same, even as technologies improve in performance and costs. We found examples of several islands where technologies have been tried or considered once and where this has led to islanders having developed either very positive or very negative attitudes to them. This can lead to rejection of technologies which might otherwise seem appropriate or can mean an attachment to some options even where those technologies do not seem likely to be economically favourable in the short to medium term. Both may require work to get citizens to buy into a technology or may mean that a technology is ruled out. The topic is itself of interest for further study since it may impact the options available to islands and other communities.

We started from the position that scenarios needed to be limited to less than 100% of total supply coming from renewables, due to constraints on potential on the islands. There is of course poitential for these constraints to be relaxed but this seemed a reasonable starting position. New innovation in technoloigies may lso iomprove the potential, either from existing sites or from sites for new technologies as they come to market. We assume that is more likely over decades than in the nect few years. We think heat pumps may offer some benefits in terms of using current electricity supply more efficienctly but that cost may act as a constraint on that happening unless tools can be found to make that more likely.

The ICE GM makes it clear there is a need for regular reconsideration of goals as regards island energy policy, as well as routes to achieving those goals. Both need to be reappraised on a regular basis. This reappraisal should also consider the evolving needs and wishes of the island citizenry and potentially also of other stakeholders.

The GM also makes it clear that state and private stakeholders need to practice transparency with the citizens impacted by changes to the energy system. This means openness about the technologies to be applied, the likely impacts on system performance, impacts on local emissions and the contribution to wider problems such as climate change, but also other potential routes to making changes. Utilities should assume that ordinary members of the public will not be as aware of the options as the utilities themselves and make efforts to give fair and balanced information to the public. Real data on effective operation of the technologies, and any impacts on costs should also be as transparent as possible.

3.7.1 Challenges specific to the Isles of Scilly

There seem likely to be some limits on siting of the selected renewable energy technologies on the Isles of Scilly, we have taken this into account to develop scenarios which gel with the target set by the IoS local government: 40% of island electricity to come from renewable sources.

While we have identified a number of potential sites available for exploitation of natural renewable energy resources on the IoS there is still potential for any concrete proposals to be blocked within the planning system. We cannot assume any ite on the island will be approved for development, given the highly protected nature of much of the island.

Further work is likely to be necessary to ensure that the concerns of citizens of the IoS are properly considered in adopting any systemic changes or as regards technology selection or placement. It was our intention to work more closely with idanders but interaction was limited by the Covid lockdown. A co-creation approach to new initiatives is essential.

The economics of renewables on the IoS are made more complex by the existence of the link to the mainland and the impact this has on what is being paid per unit in comparison to the other islands which rely on imports of diesel or other fosil fuels for the majority of their energy consumption. While bills have historically been higher on IoS than elsewhere in the UK, unit costs have been lower than where electricity has to be generated from imported diesel. However, as UK wholesale and retails electricity prices track global prices, there is greater potential for renewables to become more competitive if generated locally. How well the regulatory system works to enable the passing on of savings may become essential to whether renewables thrive on the islands.

The existence of the Isles of Scilly Smart Islands Partnership as an initiative between the islands and National Grid may offer some potential to see expert assistance inform actions to enable both reduction in energy consumption and costs, and to embed renewable energy as a key element of this.

3.8 Fostering local enterprise

As well as the varying technical nature of the products and services required in a smart energy transition, local factors mean that ‘who does what’ is likely to vary widely between settings. For example, the precise range of services providers and their contracting arrangements depend on a wide range of contextual factors such as access to capital, risk perception, legal environment, experience of contractors etc. For this reason, it is inappropriate to specify here the scope of particular contract packages. Instead, we draw from the literature that underpins these guidelines to outline the types of products and services that are likely to be needed and present a framework that communities and other stakeholders can use and adapt to map against their specific requirements.

3.8.1 Overview of key principles of GM taken from T2.1.2

In general, a smart energy transition will present commercial opportunities spanning four broad domains of commercial opportunity:

- Renewable energy supply - In most (but not necessarily all) smart energy transitions in peripheral territories, an important goal is increasing the provision of energy from renewable sources.
- Smart technologies and practices - Better or ‘smarter’ management of electricity systems through the adoption of new technologies and practices is a crucial component of a smart energy isolated system.
- Stakeholder engagement - Establishing the goals of the energy system, establishing support for action and realising the benefits of action are all crucial parts of a successful transition.
- Oversight and management - Planning, guiding and measuring the success of the system transition as a whole.

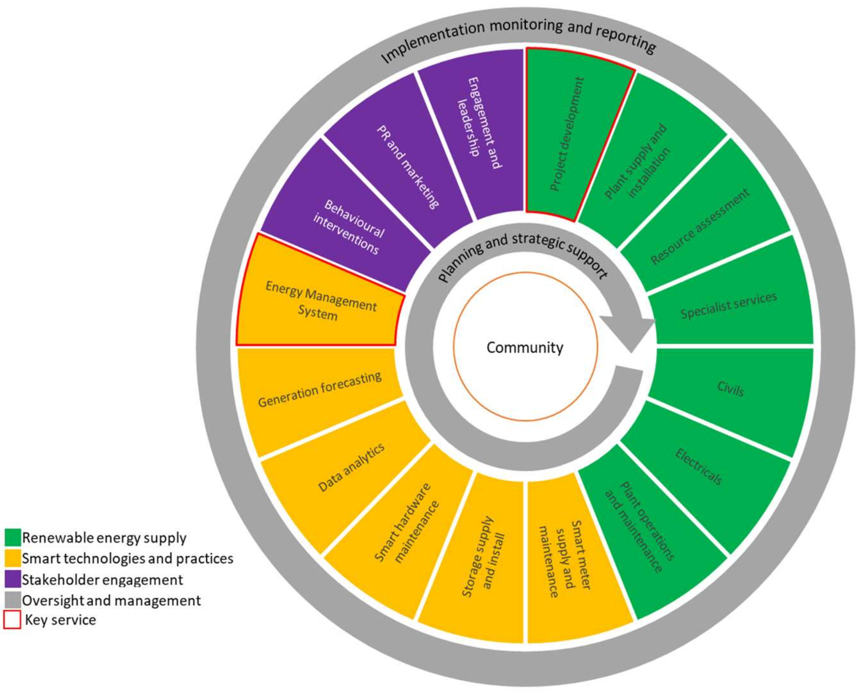

Figure 3.20 Domains of opportunity and the likely types of product and service for the transition

The ICE GM also seeks to build capacity in local businesses by providing advice on topics such as:

- Access to finance
- Innovation funding

Finally, a system of business support based on the creation of a network of businesses invited to participate in a network for collaboration and interaction.

3.8.2 Local Supply Chain Analysis

In scoping the opportunities for local businesses in delivering the energy system transformation, we drew on the above wheel as well as the value chain developed in ICE deliverable 4.1.1 (). This analysis involved three stages: reviewing the literature to identify local supplier opportunities, populating the value chain based on our future energy scenarios, and mapping service requirements to local enterprise capacities. In order to understand the type and scale of services likely to be required, we characterised the local stakeholders as well as the potential future energy system. Local capacities were evaluated through regional level Office for National Statistics (ONS, 2019) data of business capabilities as well as identifying examples of relevant local businesses using the Yell (2020) directory. The resulting information illustrates local business capacity for supporting the development of a smart energy system.

Characterise the stakeholders/users

There is a diverse set of stakeholders on the IoS, such as local residents, business owners, the Council of the IoS, the IoS Wildlife Trust, the Duchy of Cornwall, the electricity network operator Western Power Distribution, holiday house owners, and tourists.

Developing new wind turbines and large-scale solar PV is likely to cause disagreement. The development of new sites for solar PV generation is likely to generate a low level of opposition – there are over 100 existing rooftop and ground-mounted systems already installed, but some specific locations and ground-mounted arrays may prove contentious. Whilst there is a significant proportion of local stakeholders, possibly a majority, in favour of wind generation there is a substantial constituency firmly opposed to the installation of wind turbines on the islands.

The diverse nature of stakeholders and the likelihood of disagreement, especially around wind turbines, indicates that careful and appropriate stakeholder engagement will be valuable.

Characterise the energy system

On the IoS the solar PV generation is likely to be a mixture of tens of large (>10 kW) ground-mounted installations as well as hundreds of distributed, smaller (roughly 3 kW-12 kW) roof-mounted systems. Roof-top solar installations could be provided by installers local to the island or West Cornwall, though there has been a dramatic reduction in solar installers over the past few years. Ground-mounted systems differ in being generally larger scale and requiring groundworks. The larger the scale of the system, the more likely it is that larger contractors, who may be less local, will be better suited to deliver the project. Similarly for the groundworks, local groundworkers are more likely to be able to deliver smaller projects.

Any wind generation is likely to be more centralised, with fewer than ten sites. At up to 250 kW, the turbines are relatively small by industry standards but are likely to require a turbine specialist as the main installation contractor, though ancillary electrics, groundworks and other services may be provided by local businesses.

A broad programme of energy efficiency improvements in domestic properties will be needed to reduce heating costs. Measures will include cavity and solid wall insulation, as well as some loft insulation.

Capacity mapping

The overall picture which emerged from our capacity mapping was that capacity on the IoS is limited to a small number of generalised skills (e.g., construction) with increasing evidence of more specialist capacities in West Cornwall, and more again when including all of Cornwall or the Southwest UK. Some notable exceptions were the Isles of Scilly Wildlife Trust who provide specialist environmental consultancy on the islands whilst, on the other hand, there was no evidence of electricians based on the islands, though there were plenty in accessible Penzance and nearby West Cornwall. For more detail on the local capacity mapping see Appendix 1.

3.8.3 Available Funding

Grant funding

National Funding

Innovate UK offer grant support for commercial innovation, research and development. For example, as of 18th August 2020, Innovate UK is running a competition for its Sustainable Innovation Fund: round 2 (de minimis) which will fund innovative projects by businesses impacted by the Coronavirus pandemic.

Following the coronavirus pandemic, the Government's 'Getting Building' fund is supporting 'shovel-ready' building projects through Local Enterprise Partnerships.

The Department for Business, Energy, and Industrial Strategy has been running an Energy Innovation programme funding a series of projects focused particularly on renewable heating and energy efficiency.

Loan funding

National Funding

Innovate UK have provided innovation loans since 2017. Following the coronavirus pandemic, Innovate Uk announced 'innovation continuity loans' to support small and medium enterprises and 3rd sector organisations suddenly short on funds for a live project as a result of the pandemic.

The market for private loan funding is still challenging.

Equity finance

Equity finance options will depend on the incorporated nature of the organisation responsible for delivering the energy system. For example, if a community interest company were formed to deliver the new energy system, equity finance could be raised through process similar to a community share offer. This could be organised through an organisation such as the IoS Community Venture.

4 Conclusion

The ICE model suggests credible routes to the Isles of Scilly achieving 40% of its power from renewable electricity sources based on the islands. Pressures on land as well as other factors make achieving a 100% target more challenging. Transport was excluded from the assessment, since options for transport are relevaitly limited on the island, but a shift to e;lectric vehicles may offer some potential for network management but are also likely to drive demand, making it harder to hit 40% and any target beyond that.

A mix of wind and solar seems likely to be more useful in meeting demand than either technology alone. The Isles of Scilly is the only site connected to a larger mainland grid that we considered and there is a notable impact on the economics of including storage in the scenario. As in other scenarios, the cost gains in the period from 2008 to 2022 for wind and solar make them the go to technologies. It should be noted that our scenarios show an economic advantage for an approach with both a mix of solar PV generation and wind generation.

There is a much wider set of stakeholders for this island energy system compared with the other UK island in our case studies. The connection to the mainland also changes the role of UK utilities, giving the local distributiuon network operator, as well as electricity providers, more responsibility in comparison with Lundy. Again there is a need to consider any impact on tourism on the islands, and the aesthetics of solar, but perhaps more pointedly of wind energy siting. The island is subject to UK planning and the sites suggested in this study (or others) may see opposition within the planning process. It remains unclear what the final UK Government position will be on siting of both onshore wind and of solar farms.

The UK regulatory system offers more limited support for new capacity than it did at the start of this project, with the termination of new entrants to the Feed-in Tariff (FiT) in 2019, and it is unlikely that the Isles of Scilly could secure public subsidy through contracts for difference, given the dominance of larger projects with their economies of scale in the competitive auction process. As with our French island case studies, there is considerable potential for heat pumps on the Isles of Scilly, providing substantive reductions in overall electricity consumption, allowing long term economies for households as well as lowering demand and allowing any installed renewable electricity generation to go further in meeting local demand. As with other islands in the ICE studies, the relative weakness of the local economy might act to limit uptake of either the quality of material in dwellings or heat pump installation. It is not clear where the additional support that this is likely to require might come from. While the islands have made some ground with smart energy systems, EU funding has played a role in this, and is no longer available.

4.1 Assessment of validity – does the General Methodology apply in this context?

We consider the application of the ICE General Methodology (GM), and any issues arising from the approach, in an addendum to the GM, which is available as a standalone document "Lessons from application of the ICE General Methodology" from the ICE website.

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6 Appendix 1

6.1 Solar PV on the IoS

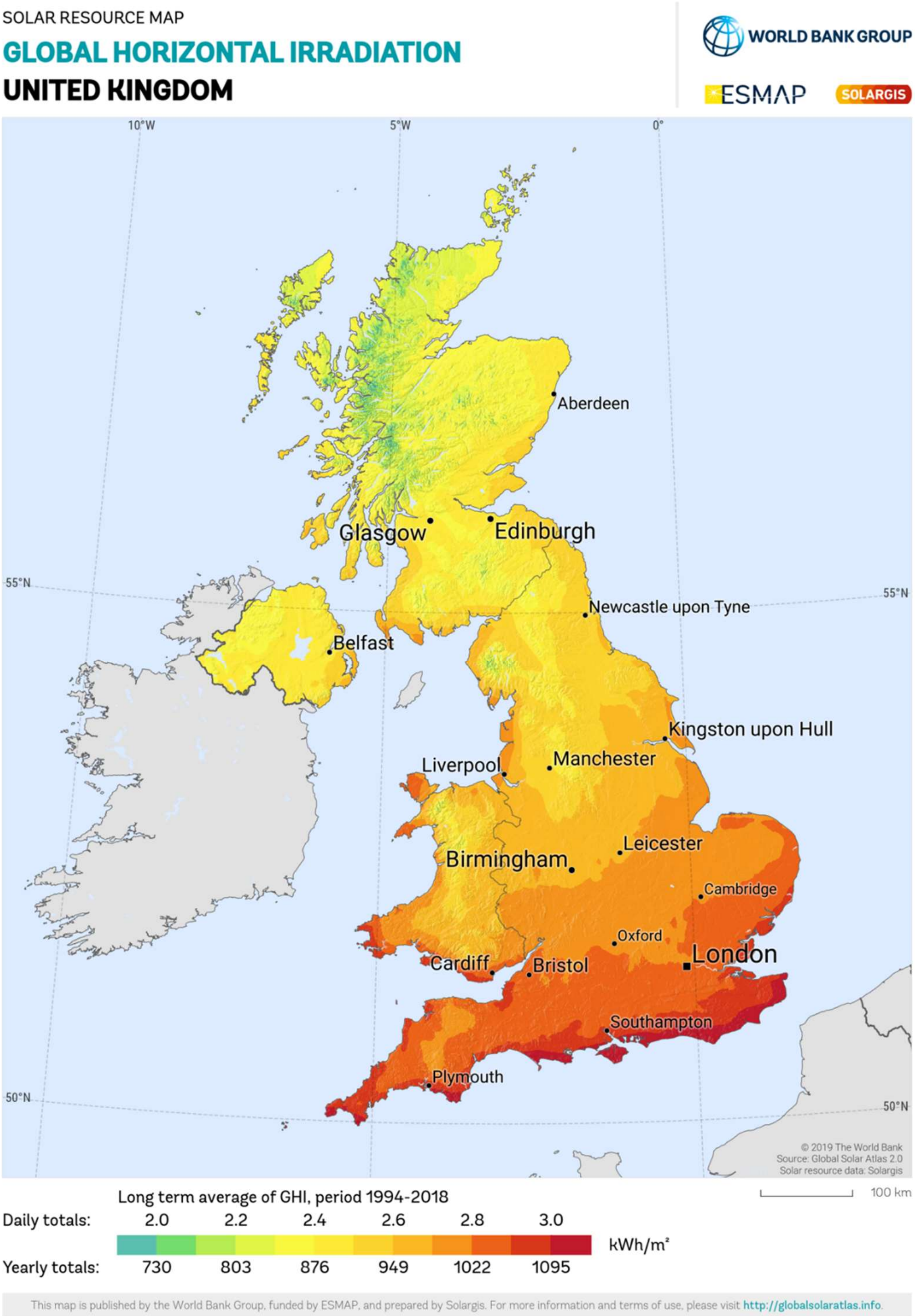

Figure 21 - Solar Geographical Information System Image of the UK

Table 11 - Irradiance values for Isles of Scilly, generated using the PVGIS- SARAH database.

Month	DNI (kWh/m^2)	GHI (kWh/m^2)	G(37°) (kWh/m^2)

January	33.36	25.30	43.63
February	50.82	44.60	67.51
March	76.73	78.76	102.03
April	124.70	131.48	150.43
May	137.70	162.98	166.20
June	136.80	170.10	166.32
July	147.29	175.69	175.72
August	124.22	141.86	153.56
September	95.84	100.94	124.53
October	70.82	63.06	90.94
November	36.42	30.29	49.18
December	27.51	20.41	36.35
Total	*1062.21*	*1145.47*	*1326.38*

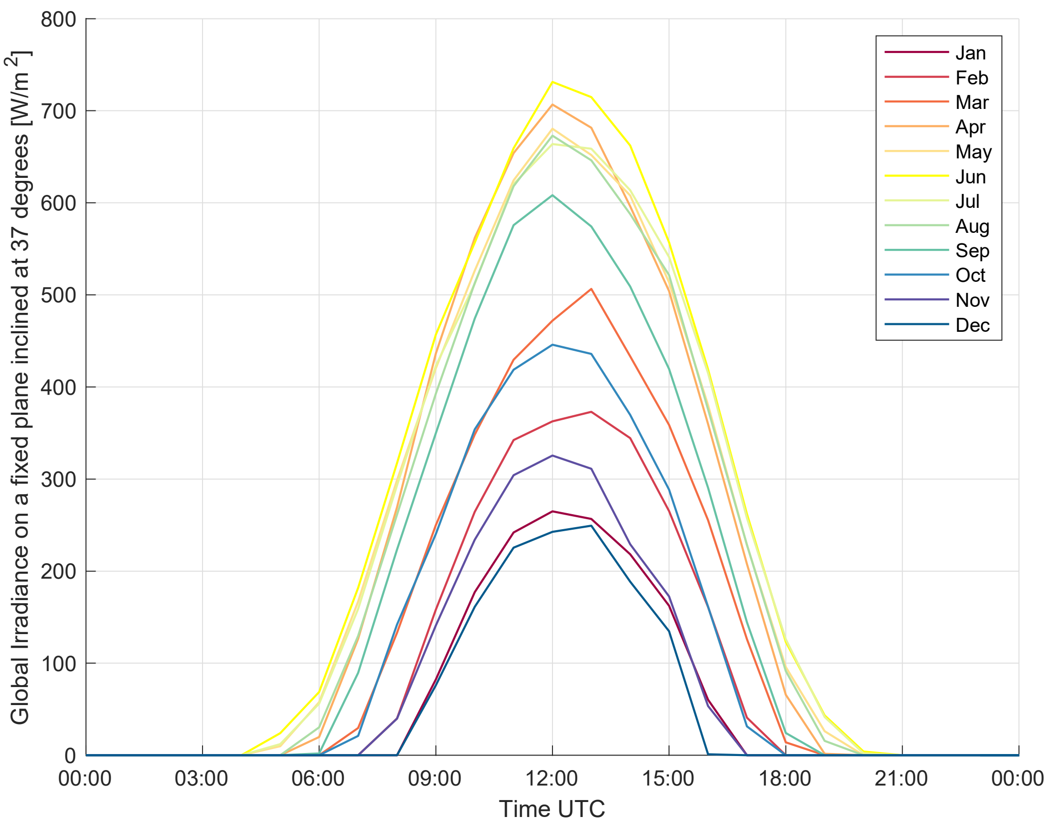

Figure 22 - Average daily irradiance for each month of the year (taken across the 5 years).

6.1.1 Protected Environments

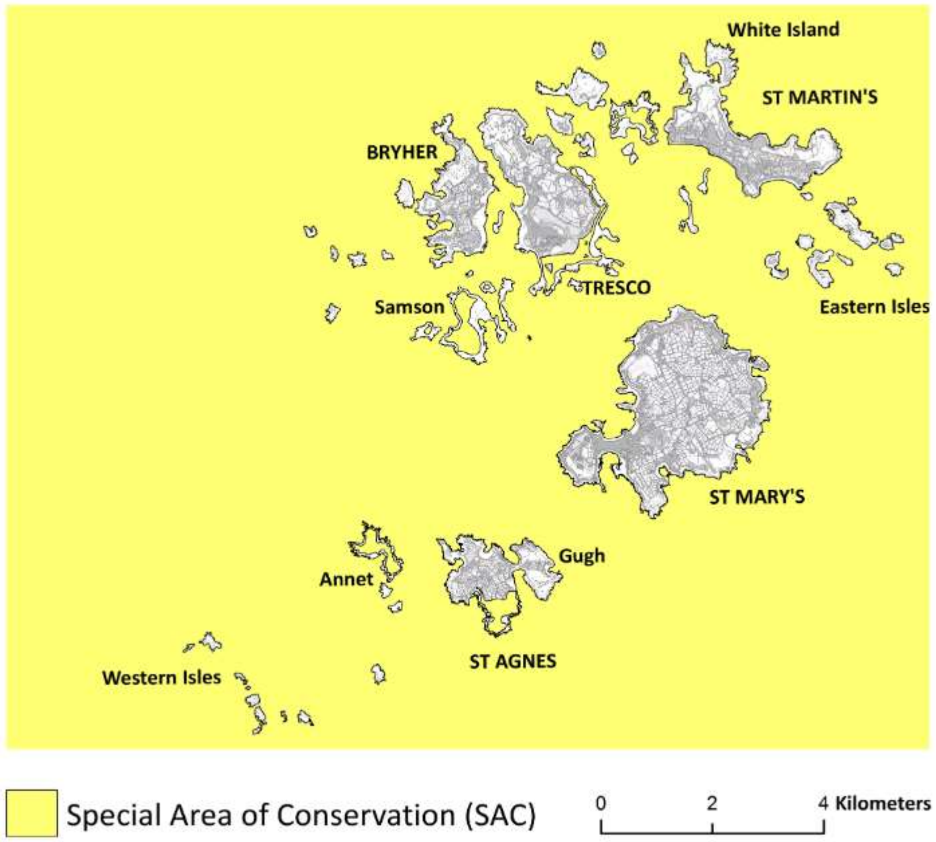

Figure 23 - Isles of Scilly Special Area of Conservation. Contains OS data © Crown Copyright Controller of Her Majesty's Stationery Office (2020).

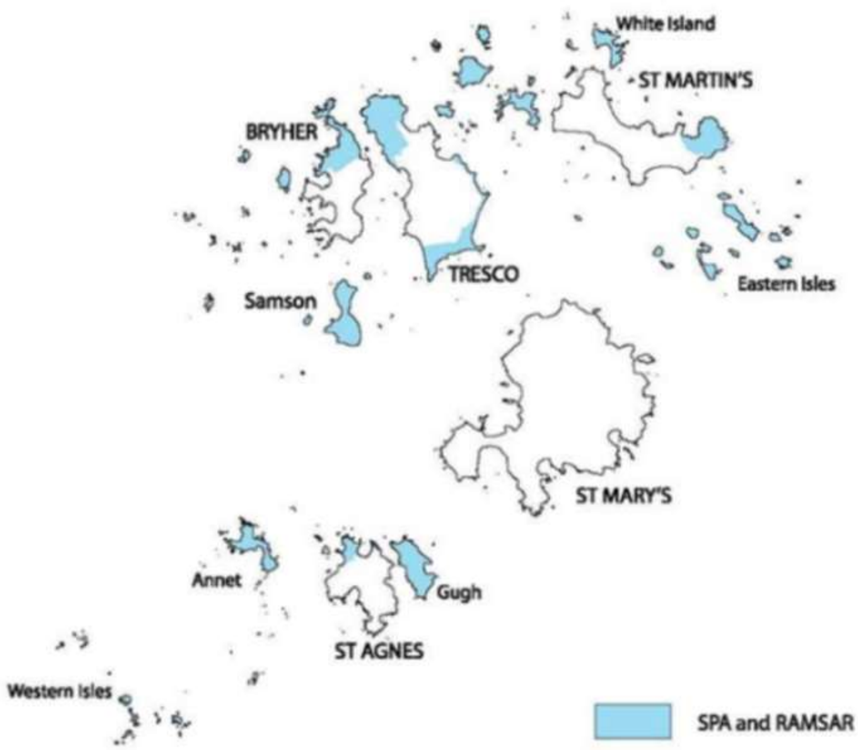

Figure 24 - Isles of Scilly Special Protected Area and RAMSAR Site. Contains OS data © Crown Copyright Controller of Her Majesty's Stationery Office (2014)

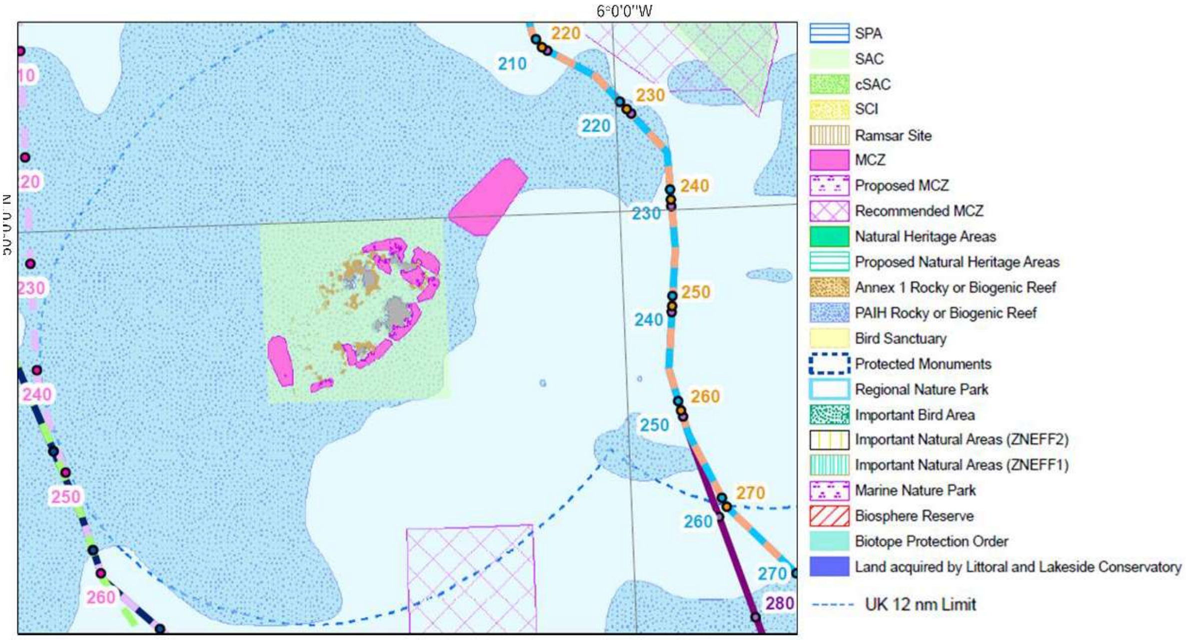

Figure 25 - Marine Environment Protected Areas

6.1.2 Scheduled Monuments and Listed Buildings

A scheduled monument is a classification given by Historic England on sites containing nationally important archaeological sites or historic buildings. Written permission is required for alterations from the UK Secretary of State for Digital, Culture, Media and Sport (DCMS). The Scheduled Monument Consent Act (1979) is enforced on activities that include: demolishing, destroying, damaging, repairing, altering, adding to the either above or below ground. Planning permission with the local authority is also required in addition to the requirements of the National Act (UK Gov, 2020).

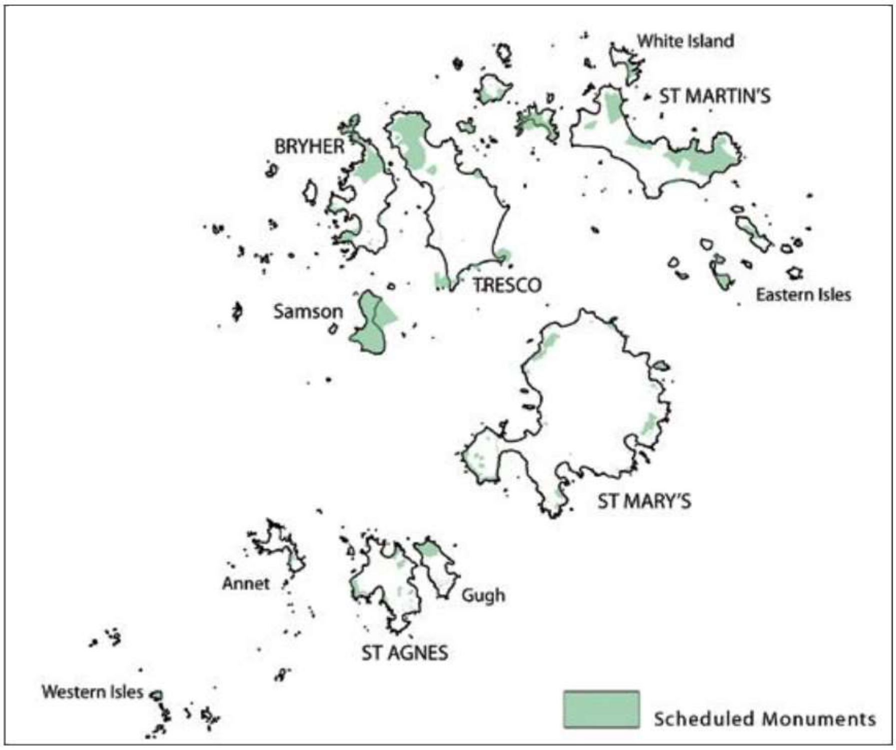

Figure 26 - Distribution of Scheduled Monuments (Council of the IoS, 2015)

There are at least 130 grade I and II listed buildings on the Isles of Scilly. Listed building consent would be required before installing solar PV panels on any of these buildings (Historic England, 2020). The distribution of these buildings on the islands is shown in Figure 27.

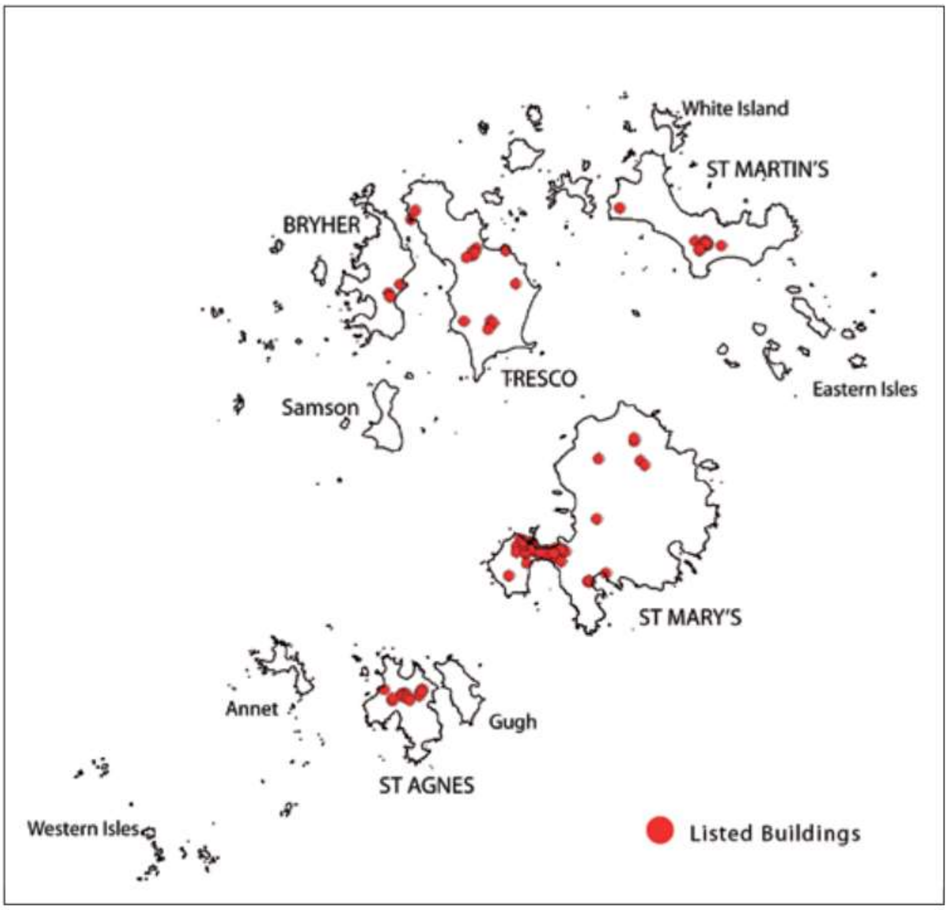

Figure 27 - Distribution of Listed Buildings (Council of the IoS, 2015)

6.1.3 Local Planning Policy

The IoS Local Plan (in Policy SS8) expresses support for renewable energy development where:

a. "they contribute towards meeting domestic, community or business energy needs within the islands;
b. they do not compromise the scenic beauty, wildlife, landscape, seascape, cultural heritage or historic environment of the islands, including any cumulative and inter-visibility impacts;
c. they protect and enhance biodiversity and the maintenance of wildlife populations such as sea birds;
d. they provide environmental enhancement and community benefits wherever possible;
e. they would not have a significant adverse effect on the amenity of local residents in terms of noise, dust, odour, reflected light, traffic or visual intrusion;
f. there would be no significant adverse effects on airport radar, air traffic control and telecommunications systems; and
g. they contribute directly to energy conservation." (Council of the IoS, 2019: p68)

6.1.4 Site Selection

There are 1,375 dwellings on the IoS. Domestic EPC data for the IoS suggest that around 14% of dwellings are flats with another dwelling above them (93 out of 657) and that 93% of roofs are pitched and 7% are flat. Extrapolations to the whole housing stock from these EPC-based assumptions are outlined in Table 12. For domestic roof-mounted solar PV a preference for installations on south-facing roofs was assumed, as incentivised by current financial incentives and to provide an indication of maximum peak power generation to inform grid constraints. We assumed all pitched roofs are at 30 degrees (Council of the IoS, 2006). Flat roofs were assumed to opt for an East-West orientation as the most space-efficient option as well as being easy and affordable to install. In all cases, a 3 kWp solar PV system was cautiously assumed, comprising 10 No. 300 Wp panels. All results assume standard test conditions.

Table 12 - Available roof-types on the IoS

Roof types	Estimated Numbers
Pitched roofs	1,099
Flat roofs	83
Below another dwelling	193
TOTAL	1,375

Using satellite data we were able to identify at least 54 warehouses and agricultural barns on the IoS whose roofs appear suitable for solar PV as shown in Figure 28. For these we assumed an equal distribution of South-facing and East-West oriented rooftops, all at a 10 degree inclination. The roof areas varied between buildings, but we cautiously assumed that an average of 12 kWp of solar PV panels could be installed on each roof aspect: one aspect (12 kWp) for South-facing roofs and both aspects (24 kWp) for East-West roofs.

Figure 28 - Agricultural barns and warehouses potentially suitable for solar on the IoS. Source: Google Earth.

6.2 Wind on the IoS

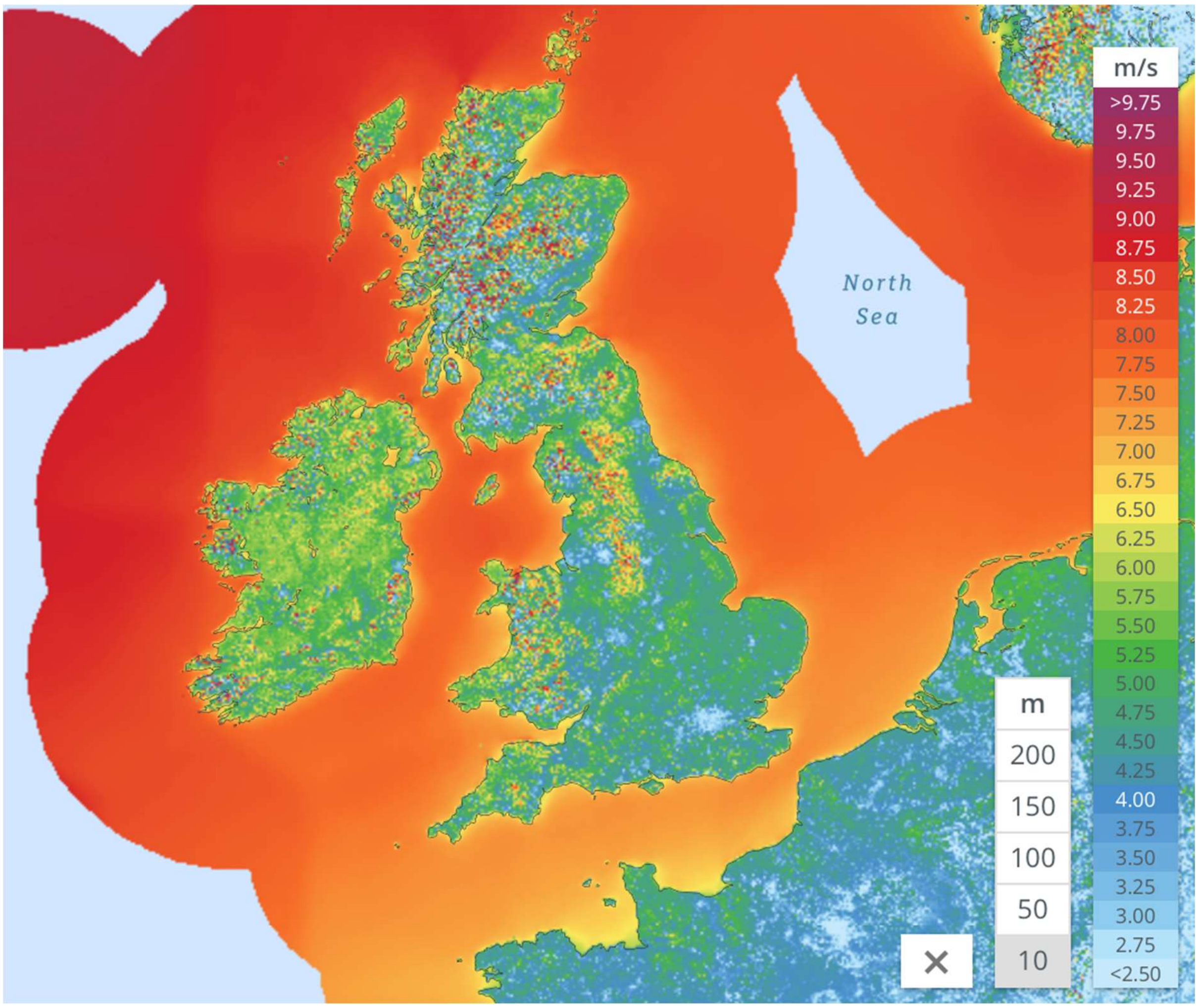

Figure 29 - Distribution of wind speed at a height of 10m (Global Wind Atlas https://globalwindatlas.info)

6.2.1 The Wind Resource

The data was scaled for desired turbine hub heights using Equation 1.

Equation 1 - Wind speed extrapolation to a particular height. Where z is the hub height of the turbine, zref is the height that the data is collected at, Vref is the speed at height zref, z0 is the roughness, and V(z) is the resultant wind speed at the hub height. (Burton et al., 2011)

$$V(z) = V_{ref} \frac{\ln\left(\frac{z}{z_0}\right)}{\ln\left(\frac{z_{ref}}{z_0}\right)}$$

To upscale windspeeds, the aerodynamic roughness length of the environment needs to be defined (Z_0). The roughness length varies for different environments, city centres have values >2m, parklands and bushes have 0.5m, and open oceans have lengths of 0.0002m. Figure 30 shows the range of roughness levels across the IoS, for this study the average value of 0.055 has been used. This is equivalent to agricultural land with some houses which is appropriate to the landscape.

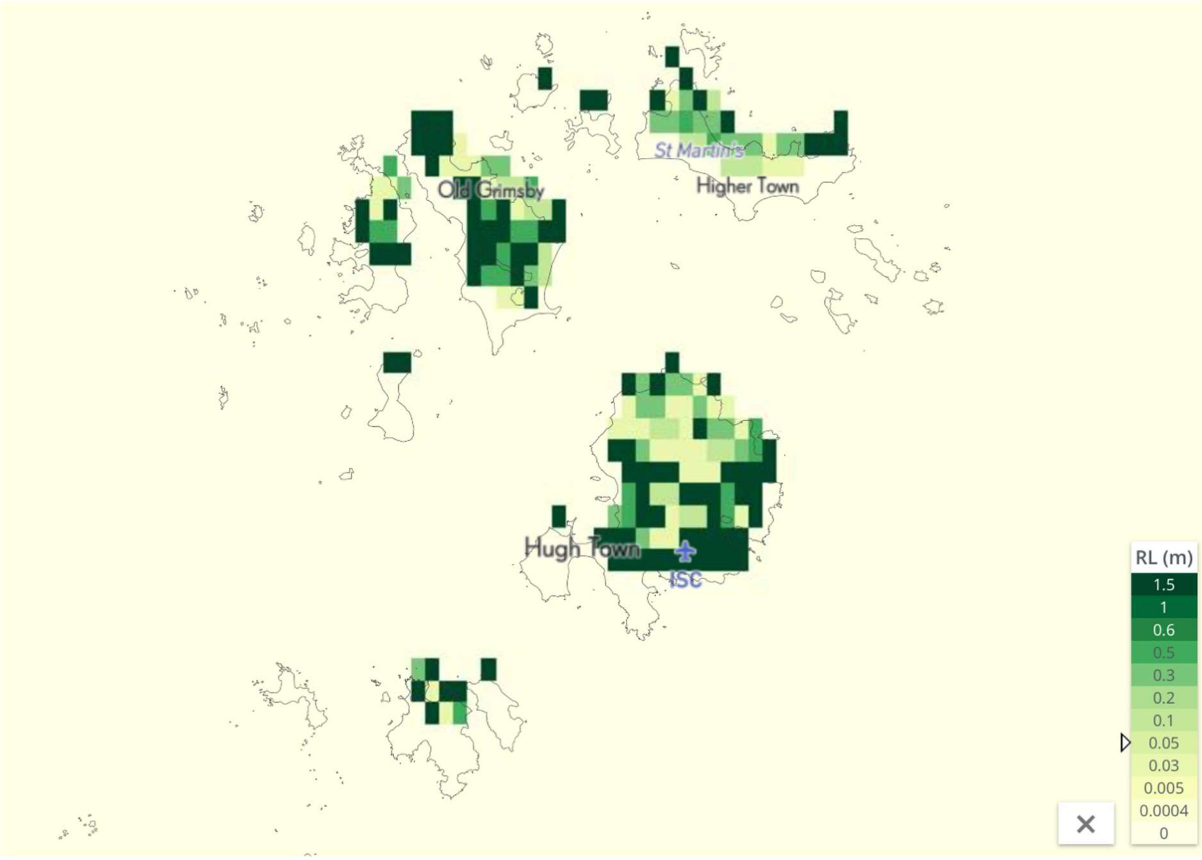

Figure 30 - Surface roughness across the Isles of Scilly according to the Global Wind Atlas

The prevailing wind direction is from the South and West with occasional Easterlies and rare Northerlies. This is shown in detail in Figure 31.

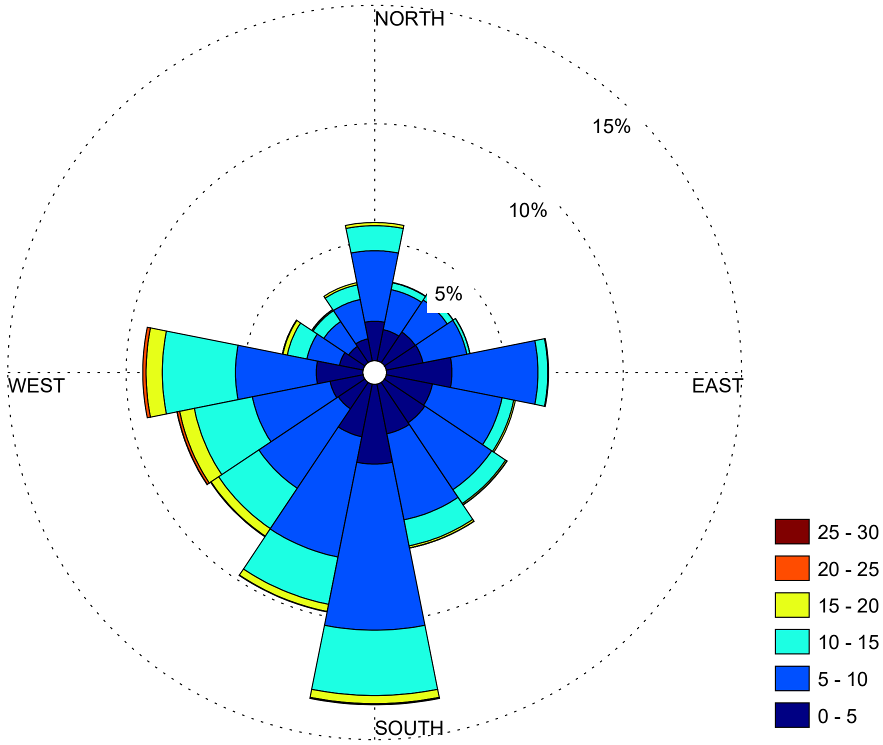

Figure 31 - Wind rose showing wind direction and intensity for NOAA data across 5 years

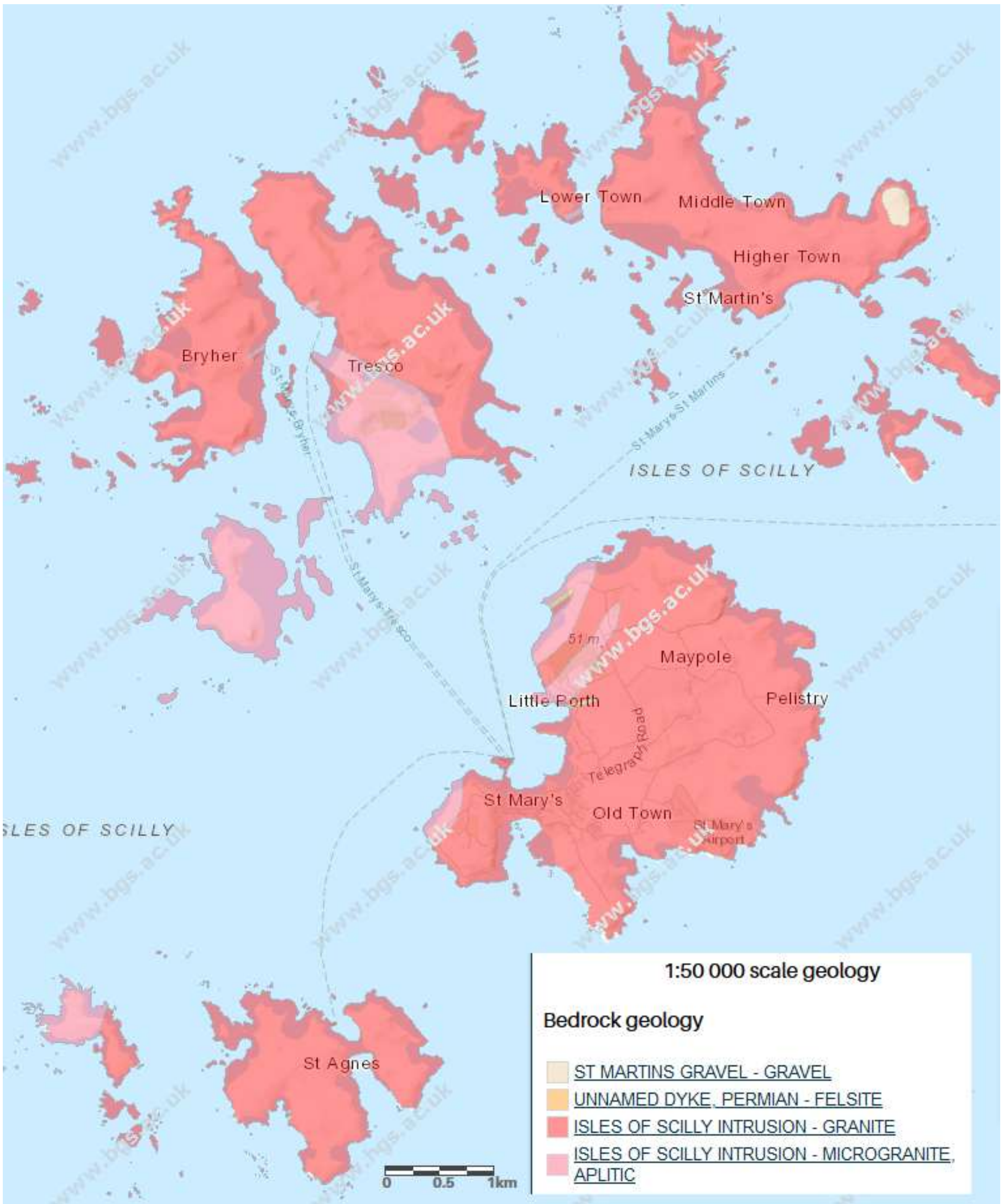

Figure 32 - Map of the bedrock of the Isles of Scilly (source: British Geological Survey)

6.2.2 Environmental and Policy Constraints

There are a number of potential environmental impacts caused by wind turbine which must be assessed and mitigated, including flickering effects, rotor noise, radar interference, visual impact, and bird collisions. The local planning process, including an Environmental Impact Assessment, will assess these impacts and their mitigation, weighting them against the energy generation benefits. In general, ensuring that the turbines are sited at an appropriate distance from residences, roads, hedgerows and woodland helps minimise impacts. Highways England state that turbines should be sited a distance of 50m plus the height of the turbine (from base to the highest point of the blades) from any buildings or roads (Department of Transport, 2013). Houses to the north of the turbine within a distance of ten rotor diameters are likely to experience flickering from the turbine's shadow (Local Government Association, 2020) whilst those more than 350 metres away are unlikely to experience any sound above ordinary background noise (35-45 dB(A)) (Government Planning Portal, 2000). A 50m buffer from hedges is suggested by Natural England as mitigation minimum and is what is used in the site selection model below (Natural England, 2009).

The visual impact of a wind turbine would be substantial on the IoS. For a turbine to generate electricity efficiently, it must be the tallest structure around, therefore, it will always be visible from certain perspectives. We were unable to carry out local stakeholder engagement within this study to understand in detail local sentiment. However, it is clear that opinion is divided on the IoS with strong opposition among at least some residents as well as a constituency in favour (IoS Council, 2015; IoS Community venture, personal communication).

Since 2015, national planning policy guidance has suggested that for a wind turbine over 11m tall to obtain planning permission it must be on a site identified in the Local or Neighbourhood Plan. In the case of the IoS, the Local Plan 2015-2030 states that opportunities for wind turbines are “likely to be limited” (Council of the IoS, 2019: p68) due to their impact on the landscape, “no site has been subject to a full assessment. Due to the scale of the islands, it has not been possible to identify a site for onshore wind” (IoS, 2019: p68). In this context, it appears unlikely that a wind turbine would be granted planning approval in the short term.

6.3 Power Flow and Reliability Analysis

6.3.1 Power Demand at each load node

This study will analyse the high voltage network on the IoS. In order to derive the power demand at each node, a catchment area was drawn around the node identified in the IoS power network map provided by WPD [Distribution, 2020 #366] for each island as shown in Figure 33 to Figure 37. The load of each node is determined based on the number of properties located within each catchment.

Figure 33 - St Marys load node catchment area

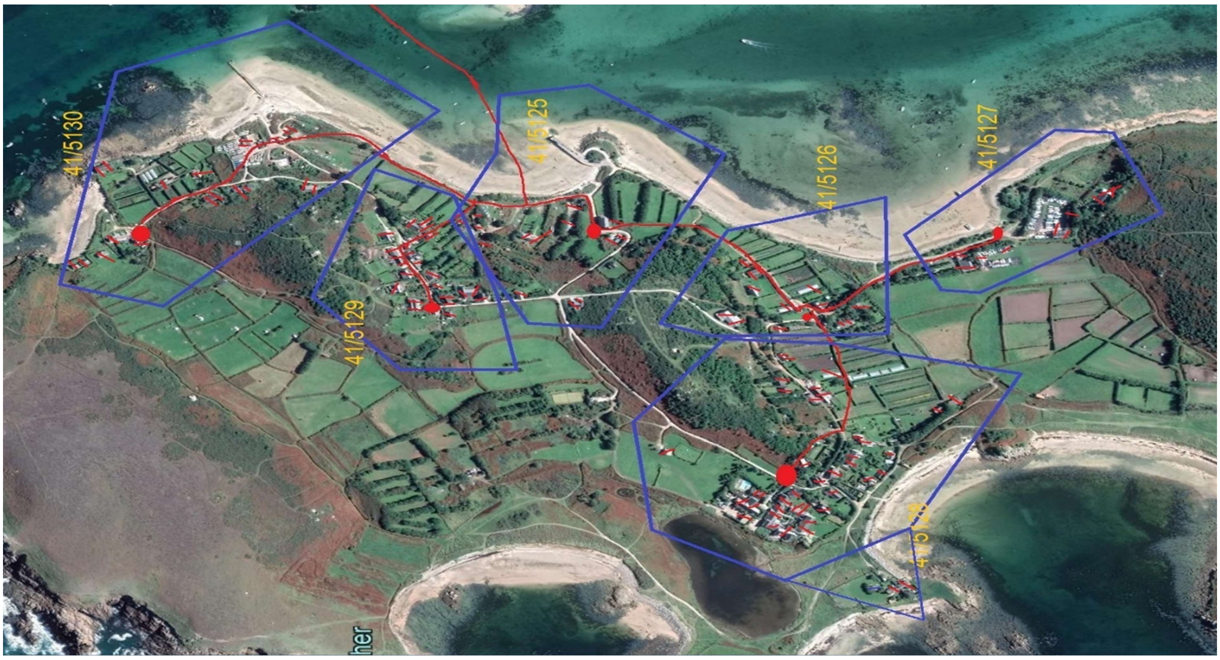

Figure 34 - Bryher load node catchment area

Figure 35 - St Agnes load node catchment area

Figure 36 - St Martins load node catchment area

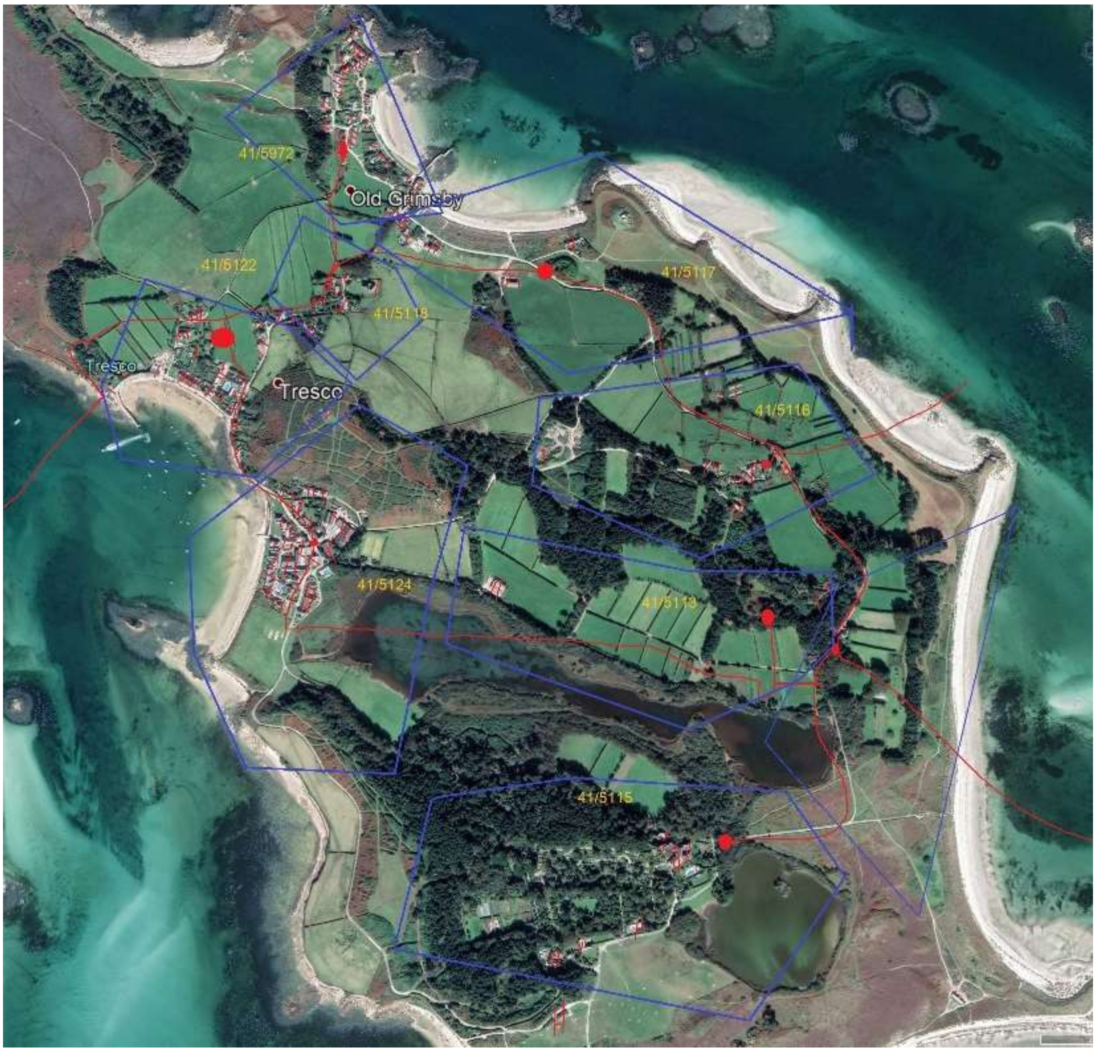

Figure 37 - Tresco load node catchment area

Based on the number of houses, maximum power demand (4.92MW) and power factor 0.9, the active and active power of each load node are calculated as shown in Table 13. The labels of the load nodes are taken from the WPD interactive maps. The load nodes are labelled as XX/YYYY where the first part is the network number, see Figure 3Error! Reference source not found., and the second one is the load node number. For simplicity, only the load node number is considered where all the networks are connected tighter. Further details about the load nodes and power network will be shown in the next sections.

Table 13 - Number of properties, active power and reactive power for each load node of the islands.

The methodology to get the power demand at each load nodes has some uncertainty. For instance, the nature of business of the house, i.e. is it a hotel, shop, barn or normal house? However, the power flow analysis is carried out at the peak load demand which means most of the business are open and most of the people including the tourism are on the island. It is expected that there will be an error in power flow analysis depending on the availability of the required data.

After we have the power demand at each node, the cable parameters are calculated as in T1.2. WPD offers interactive maps where cable length can be calculated [Distribution, 2020 #366], see **Figure 38**. The capable length, resistance, inductance and capacitance are shown in **Table 14Error! Reference source not found.** based on the equations in T2.1.

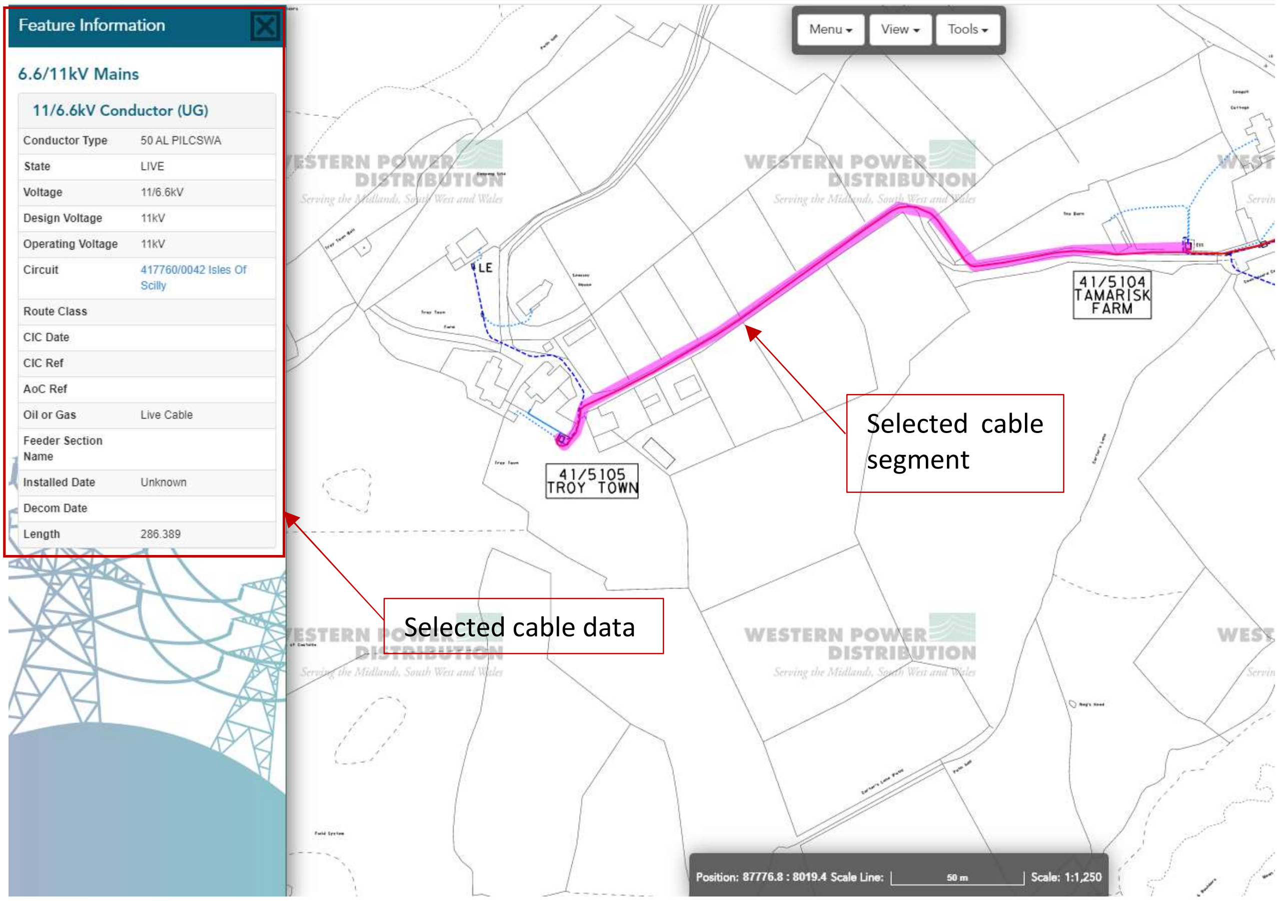

Figure 38- Interactive map for cable length, type and cross-section

Table 14 - Cable parameters of Bryher Island

Cable segment	Length [m]	cable size [mm^2]	R [Ω]	C (μ F)	L (mH)
5008 to 5010	196.384	95	0.055	0.07	0.13008
5010 to 5035	1006.944	95	0.281	0.37	0.66699
5035 to BJT	152.754	25	0.162	0.03	0.14699
BJT to 5033	58.36	25	0.062	0.01	0.05616
5033 to 41w6	130.76	25	0.139	0.03	0.12582
41w6 to 41w8	169.921	25	0.180	0.04	0.16351
41w6 to 5032	202.433	95	0.056	0.07	0.13409
41w8 to 5022	100.341	25	0.106	0.02	0.09655
41w8 to 41w10	129.623	25	0.137	0.03	0.12473

Cable segment	Length [m]	cable size [mm^2]	R [Ω]	C (µ F)	L (mH)
41w10 to 5024	36.208	25	0.038	0.01	0.03484
	51.824	185	0.007	0.03	0.02799
	137.688	95	0.038	0.05	0.09120
41w10 to 5023	137.99	25	0.146	0.03	0.13278
5023 to 5021	138.764	25	0.147	0.03	0.13353
5021 to ABI618	218.114	25	0.231	0.05	0.20988
ABI618 to 41w18	205.385	25	0.218	0.04	0.19763
41w18 to 5026	247.268	25	0.262	0.05	0.23793
41w18 to 5029	222.214	25	0.236	0.05	0.21382
	53.854	185	0.008	0.03	0.02909
5029 to 41w25	256.294	25	0.272	0.06	0.24662
41w25 to 5030	62.319	25	0.066	0.01	0.05997
5030 to 5014	196.08	25	0.208	0.04	0.18868
5014 to 5016	256.071	25	0.271	0.06	0.24640
5016 to 5036	247.992	95	0.069	0.09	0.16427
5008 to 5020	279.196	25	0.192	0.06	0.26866
5020 to 7760	290.351	25	0.200	0.06	0.27939
BJT to 5799	71.575	95	0.020	0.03	0.04741
	206.022	25	0.142	0.04	0.19824
5744 to 41X4	364.503	95	0.102	0.13	0.24144
	286.397	25	0.304	0.06	0.27558
41X4 to 5018	178.899	25	0.190	0.04	0.17214
41X4 to 5011	165.816	25	0.176	0.04	0.15956
5011 to 41X10	252.617	25	0.268	0.05	0.24308
41X10 to ABI618	129.72	25	0.138	0.03	0.12482
41X10 to 5025	262.227	25	0.278	0.06	0.25233
5025 to 5038	269.183	25	0.285	0.06	0.25902
5038 to 5019	180.849	25	0.192	0.04	0.17402
5025 to 41X16	210.196	25	0.223	0.05	0.20226
41X16 to 41XC5	403.836	25	0.428	0.09	0.38859
41XC5 to 5034	326.299	25	0.346	0.07	0.31398
41XC5 to 5027	199.89	25	0.212	0.04	0.19234
41X16 to 41X18	169.76	25	0.180	0.04	0.16335

Cable segment	Length [m]	cable size [mm^2]	R [Ω]	C (µ F)	L (mH)
41X18 to 5028	140.663	25	0.149	0.03	0.13535
41X18 to 41X21	240.299	25	0.255	0.05	0.23123
41X21 to 5037	247.569	25	0.262	0.05	0.23822
41X21 to 41X23	191.616	25	0.203	0.04	0.18438
41X23 to 5007	282.653	25	0.300	0.06	0.27198
5005 to 5007	262.234	25	0.278	0.06	0.25233
5005 to ABI728	187.48	25	0.199	0.04	0.18040
	372.961	150	0.066	0.17	0.21502
St Marys to Tresco	70.302	95	0.020	0.03	0.04657
	271.549	95	0.076	0.10	0.17987
	2869.57	50	0.987	0.81	2.28950
ABI728 to 41w55	32.99	25	0.035	0.01	0.03174
41w55 to 5013	84.202	25	0.089	0.02	0.08102
5013 to 50000	122.439	25	0.130	0.03	0.11782
	328.788	95	0.060	0.12	0.21779
41W55 to 5100	37.22	95	0.010	0.01	0.02465
St Marys to St Martin's	37.22	95	0.010	0.01	0.02465
	3159.74	50	1.087	0.89	2.52101
	427.505	50	0.227	0.12	0.34109
41w55 to 5006	291.149	25	0.309	0.06	0.28016
5006 to 5004	458.214	25	0.486	0.10	0.44091
5004 to 5012	264.837	25	0.281	0.06	0.25484
5012 to 41w39	166.387	25	0.176	0.04	0.16011
41w39 to 5001	136.988	25	0.145	0.03	0.13182
5001 to 41w36	242.622	25	0.257	0.05	0.23346
41w36 to 5015	87.81	25	0.093	0.02	0.08449
5015 to 41X23	60.429	25	0.064	0.01	0.05815
41w39 to 5031	296.241	25	0.314	0.06	0.28506
41W36 to 5681	227.38	25	0.241	0.05	0.21880
	92.713	185	0.013	0.05	0.05007
41W25 to 5681	589.817	25	0.625	0.13	0.56755
41X10 to ABI618	129.72	25	0.138	0.03	0.12482
St Marys to St Agnes	6167.9711	50	2.121782	1.74	4.92114

Cable segment	Length [m]	cable size [mm^2]	R [Ω]	C (μ F)	L (mH)
Bryher					
5127 to 5126	221.406	50	0.117	0.06	0.17665
5128 to 5126	293.674	50	0.156	0.08	0.23431
5126 to 5125	309.89	50	0.164	0.09	0.24725
5125 to BJT	178.887	50	0.095	0.05	0.14273
BJT to 5129	227.028	50	0.120	0.06	0.18114
BJT to 41/5130	456.023	50	0.242	0.13	0.36384
Tresco					
5124 to 5122a	102.048	95	0.028	0.04	0.06760
5124 to 5122b	1646.232	25	1.745	0.35	1.58408
5122 to TR5	59.67	25	0.063	0.01	0.05742
Tresco to Bryher	123.983	25	0.131	0.03	0.11930
	914.166	50	0.314	0.26	0.72937
	33.05	95	0.009	0.01	0.02189
TR5 to TR1	316.965	25	0.336	0.07	0.30500
TR1 to 5118	36.72	25	0.039	0.01	0.03533
TR1 to 5972	245.038	95	0.068	0.09	0.16231
5972_a to 5117	3672	25	3.892	0.79	3.53337
5972_b to 5117	498.043	25	0.528	0.11	0.47924
5117 to TJT	468.618	50	0.248	0.13	0.37389
TJT to 5116	213.268	50	0.113	0.06	0.17016
Tresco to St Martins	2080.585	50	1.103	0.59	1.66000
5114 to BJT	209.769	50	0.111	0.06	0.16737
BJT to 5113	61.212	50	0.032	0.02	0.04884
BJT to 5124	1047.274	95	0.292	0.38	0.69370
5124_a to 5122	111.09	95	0.031	0.04	0.07358
5124_b to 5122	366.461	25	0.388	0.08	0.35263
5114 to 5115	390.299	50	0.207	0.11	0.31140
St Martins					
5110 to 5111	132.986	50	0.070	0.04	0.10610
5110 to 5109	346.55	50	0.184	0.10	0.27650
5109 to 5108	472.737	50	0.251	0.13	0.37718
5108 to 5107	250.489	50	0.133	0.07	0.19985

Cable segment	Length [m]	cable size [mm^2]	R [Ω]	C (µ F)	L (mH)
5107 to 5106	318.257	50	0.169	0.09	0.25392
St Agnes					
5105 to 5104	286.389	50	0.152	0.08	0.22850
5104 to 5102	274.296	50	0.145	0.08	0.21885
5102 to 5103	467.255	50	0.248	0.13	0.37280
5102 to 5101	339.088	50	0.180	0.10	0.27054

Depending on the load at each node, a schematic diagram of the island power system and cable parameters, the cable Simulink model of the Isles of Scilly is shown in **Figure 39**. There are some assumptions such as:

1- The voltage at the connection point from the Cornwall to the St Marys is regulated to compensation the voltage drop due to the length of the undersea cable.
2- All the circuits in Figure 3 (Circuit 41, 42, 43 and 44) are connected at some points to make one circuit for the whole islands.
3- There is no voltage compensation (by transformer tap change) at the other for islands (St Martins, Tresco, Bryher and St Agnes).
4- Only the HV grid is considered.

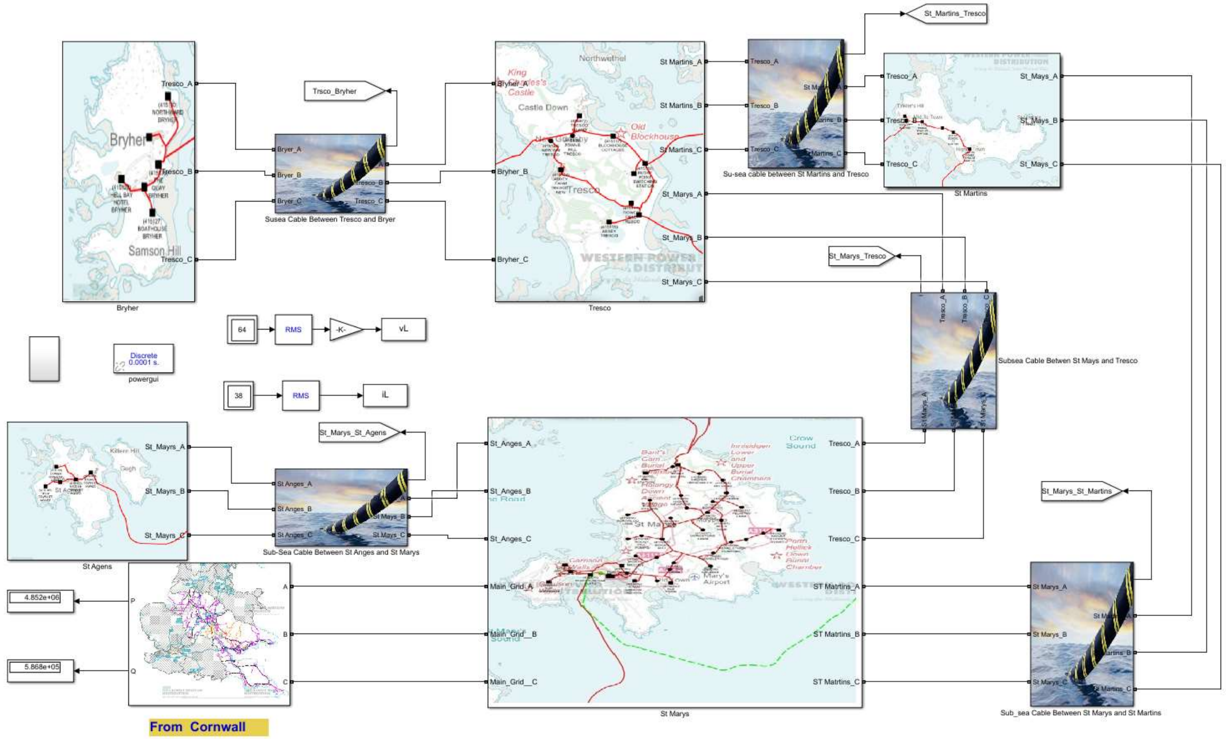

Figure 39 - Isles of Scilly Matlab Simulink Model

According to the results of the power flow analysis, the voltage drops at each load node are shown in

Bryher island has the highest voltage drops where there is no direct connection with the St Marys. Tresco is connected to the St Marys via a direct connection and via St Martins which increase the voltage drop. The maximum voltage drop is around 4% at Bryher island which is within the voltage tolerance limit (+/-6% for 11kV).

The cable capacity usage for the IoS is shown in Figure 41. Due to St Marys is the main supply for all other islands, the capable capacity usage is quite high around 72% but this value is calculated at the maximum load demand in a year which means the average of cable capacity usage could be lower than 72%. St Agnes and Bryher have the lowest cable capacity usage due to the light load demand, around 8% of total power demand.

For the reliability analysis, the same assumption and topology for Ushant Island in T1.2 will be repeated for IoS. The results for the reliability analysis for each load node are shown in Figure 42. It is obvious the farther from the main connected node with the Cornwall, the more failure rate. The highest failure rate is around 0.25 at St Agnes which quite high. It means that for every year the is a least 2 failures.

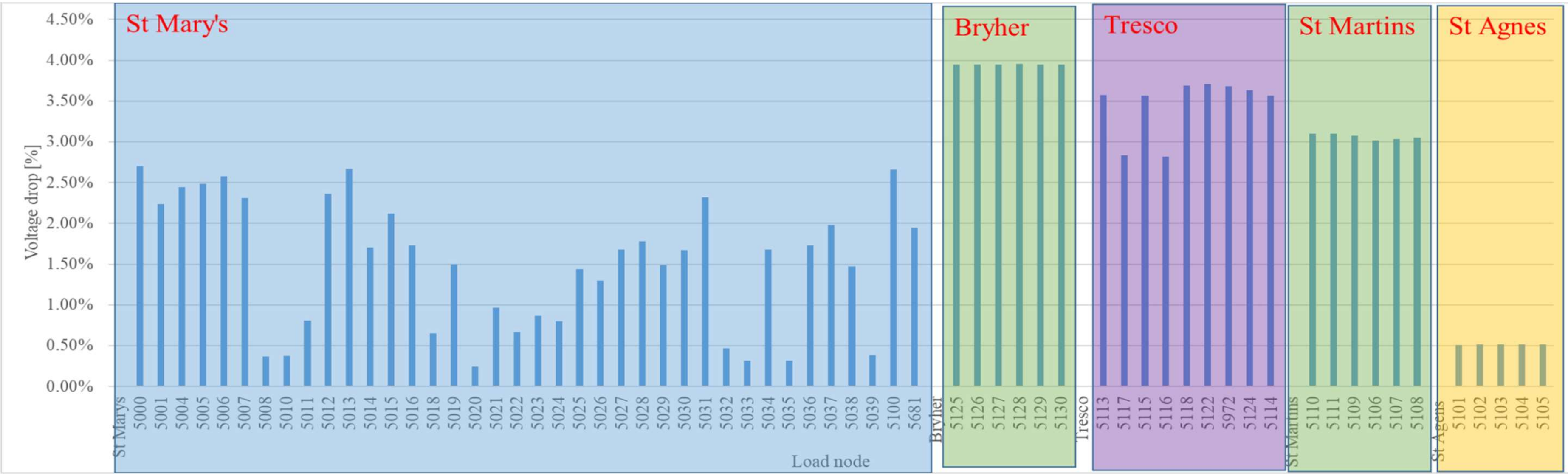

Figure 40: Isles of Scilly load nodes voltage drops

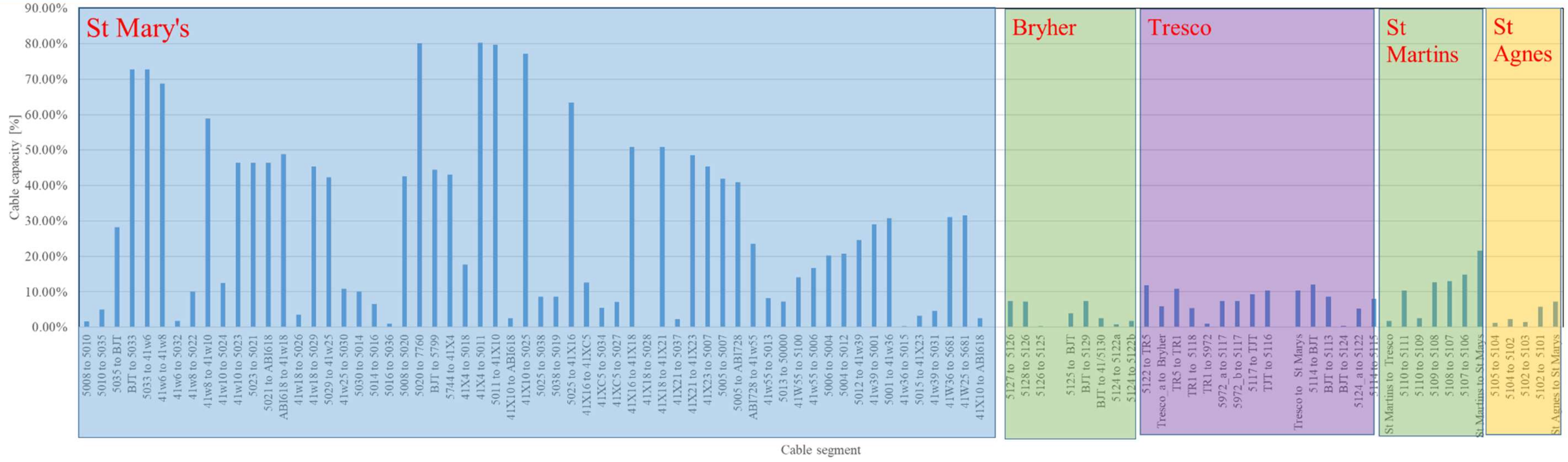

Figure 41: Isles of Scilly cable capacity

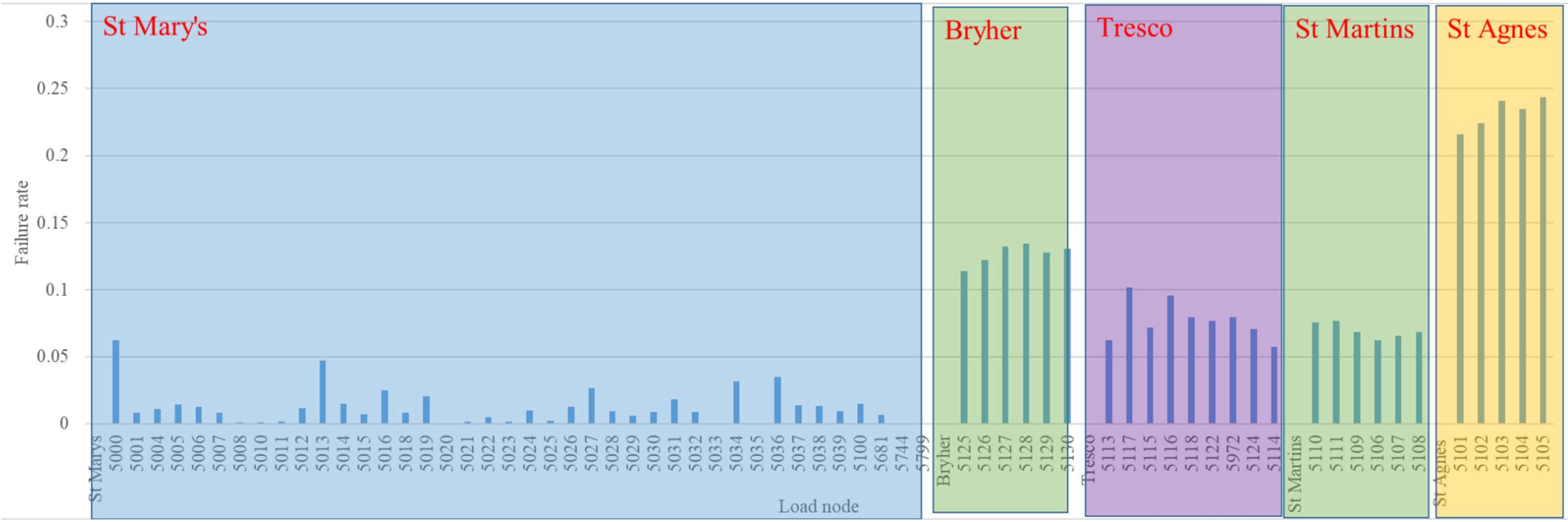

Figure 42: Isles of Scilly load node failure rate

6.4 Estimating potential energy efficiency savings.

Using national statistics for domestic heating energy consumption (BEIS, 2020), EPC records to account for heating fuel (69% electricity) and property size, and the IoS council data on occupancy (71% occupied year-round; REF), we calculated that a best estimate of the electricity consumed for heating in the properties occupied year-round on the IoS is 10,414 MWh. Using the information from the EPCs we determined the proportion of household energy which each recommended efficiency measure would save and the proportion of properties to which each measure could be applied. We looked at cavity wall insulation (17% saving in heat energy), loft insulation (10% saving) and solid wall insulation (24% saving). Our calculations indicate that applying these to all properties for which they are appropriate and which do not currently have them installed would cut heating energy by 18% overall, totalling 1,849 MWh annually.

Table 15 - Potential Heating Energy Efficiency on the IoS

Domestic Heat Energy on the IoS (sources)		
Domestic properties on the IoS (IoS Council, 2016)	1,375	
Percentage of IoS EPCs detailing electric heating (EPC data)	69%	
Estimated properties with electric heating	948	
Mean size of IoS electrically heated properties (m^2) (EPC data)	83	
% of properties occupied year-round (IoS Council, 2016)	71%	
UK mean domestic energy consumption (kWh/m^2)	227	
Proportion of energy consumed as heat (BEIS, 2020)	81%	
Total heat consumption of occupied, electrically heated domestic properties (MWh)	10,414	
Efficiency measures and savings	**Mean household saving**	**Estimated IoS savings if applied to all properties with the feature**
Heat energy saving from cavity wall insulation (EPC data)	17%	4%
Heat energy saving from loft insulation (EPC data)	10%	4%
Heat energy saving from solid wall insulation (EPC data)	24%	10%
Total heat energy saving		*18%*
Estimated potential annual electric heat saving across the IoS	1,849 MWh	

6.5 Scenarios – Renewable Energy Grid Impact Assessment

6.5.1 Ren

In this scena unted PV. It assumed th PV is near to the airport

Figure 43 - Ground-mounted PV location

The power flow analysis of the islands under scenario 1 is done under maximum power demand and the maximum output of renewable energy. The date for the power demand and output from renewable energy at maximum load demand or renewable energy sources are shown in Table 16. If there is much power generation from the PV than the load demand, a big damp resistance is placed at the city centre. This means no energy feedback to the utility grid.

Table 16 - Load and renewable energy power data under Scenario 1

	At Maximum Load	At Maximum RE
Total Load demand	4.73 MW	2.15 MW
Rooftop PV output	0.12 MW	0.12 MW
Ground-mounted PV output	0.03 MW	0.39 MW

According to the number of houses at each load node, the power demand for each node is generated. The voltage drop at maximum load and maximum RE output are shown in Figure 44 and Figure 45 respectively. The voltage drop is high at maximum load and reaches to more than 3.5%. At maximum RE output, the maximum voltage drop is 1.45% this is due to the load demand is low.

The cable usage capacity under two conditions, maximum load and maximum RE output power, are shown in Figure 46 and Figure 47. At maximum load, the cable usage capacity is quite high especially at the city centre of St Mary’s, nearly 80%.

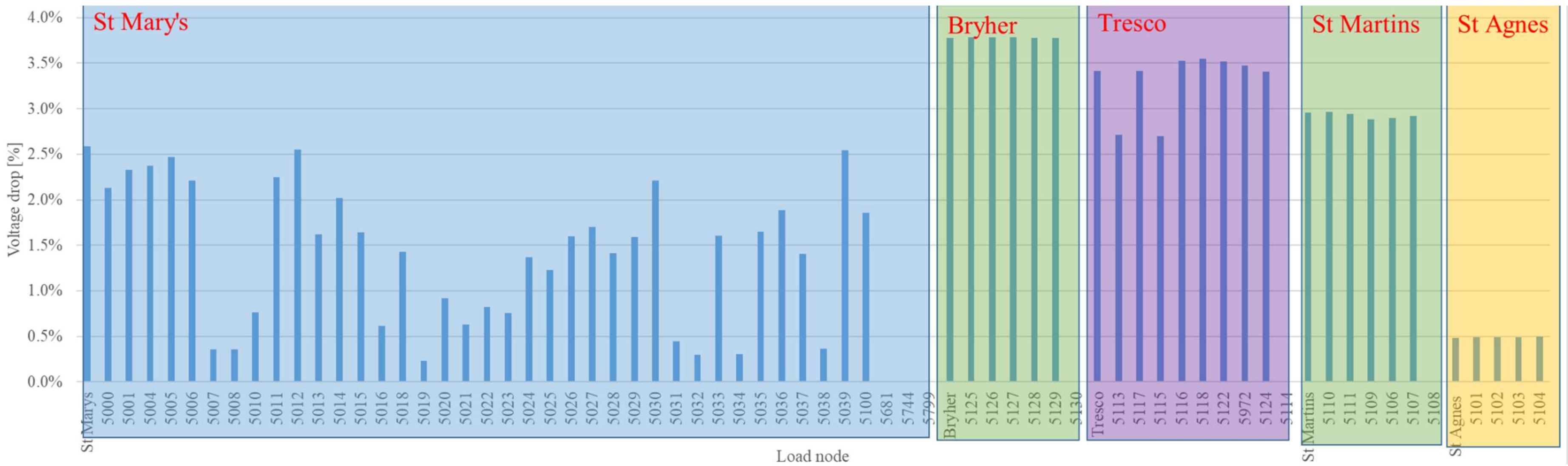

Figure 44: Load node voltage drop at maximum load scenario 1

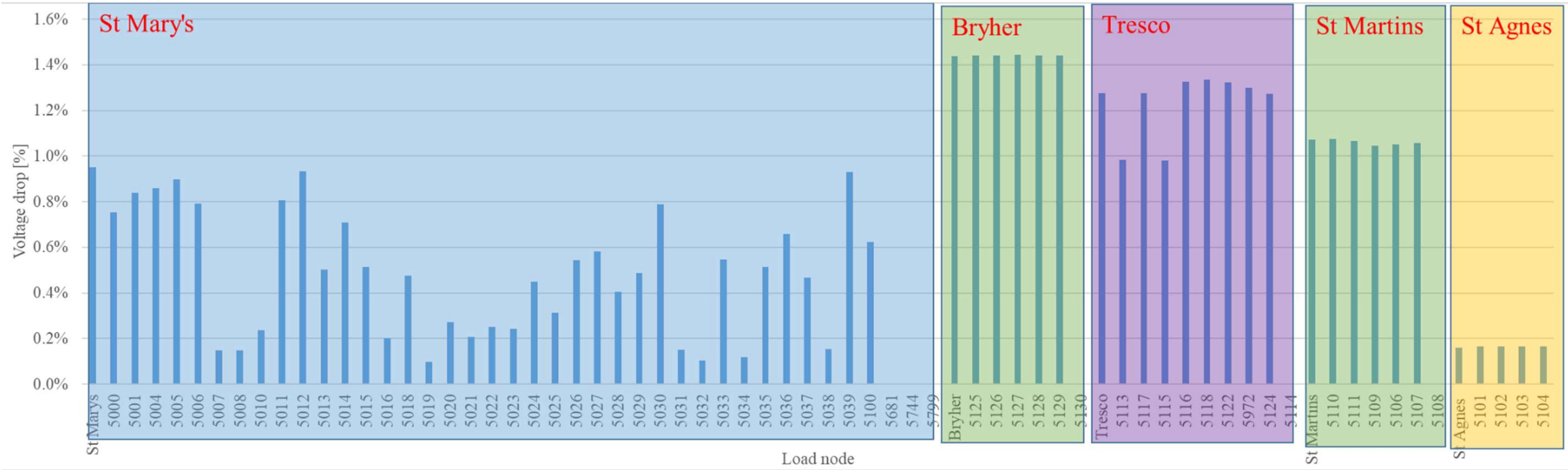

Figure 45: Load node voltage drop at maximum RE output power scenario 1

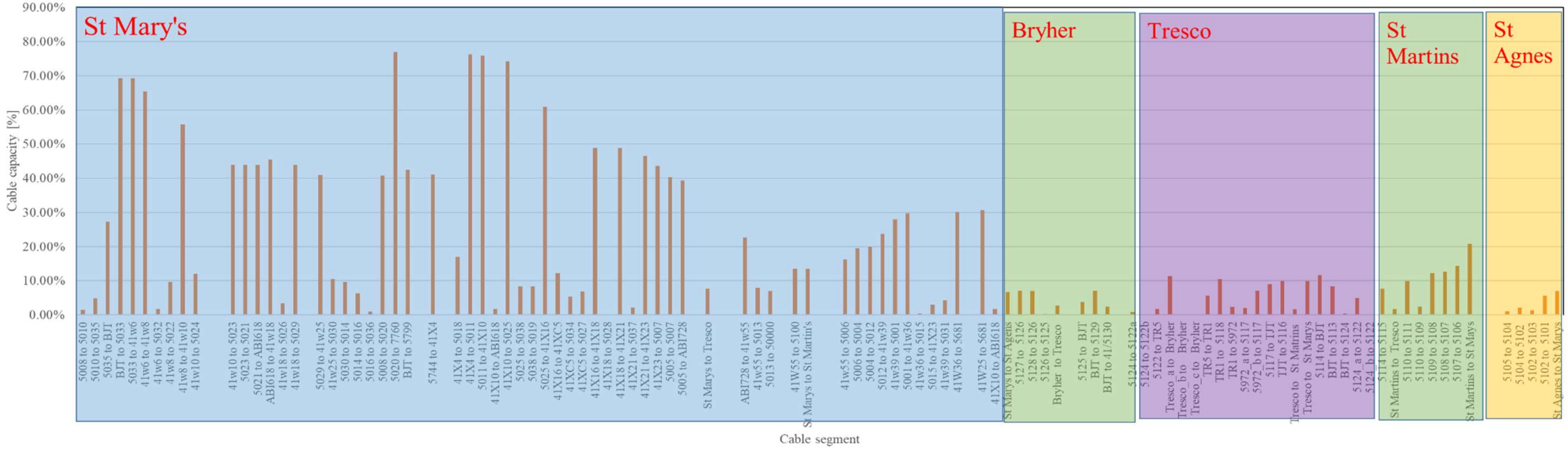

Figure 46 - Cable usage capacity at maximum load scenario 1

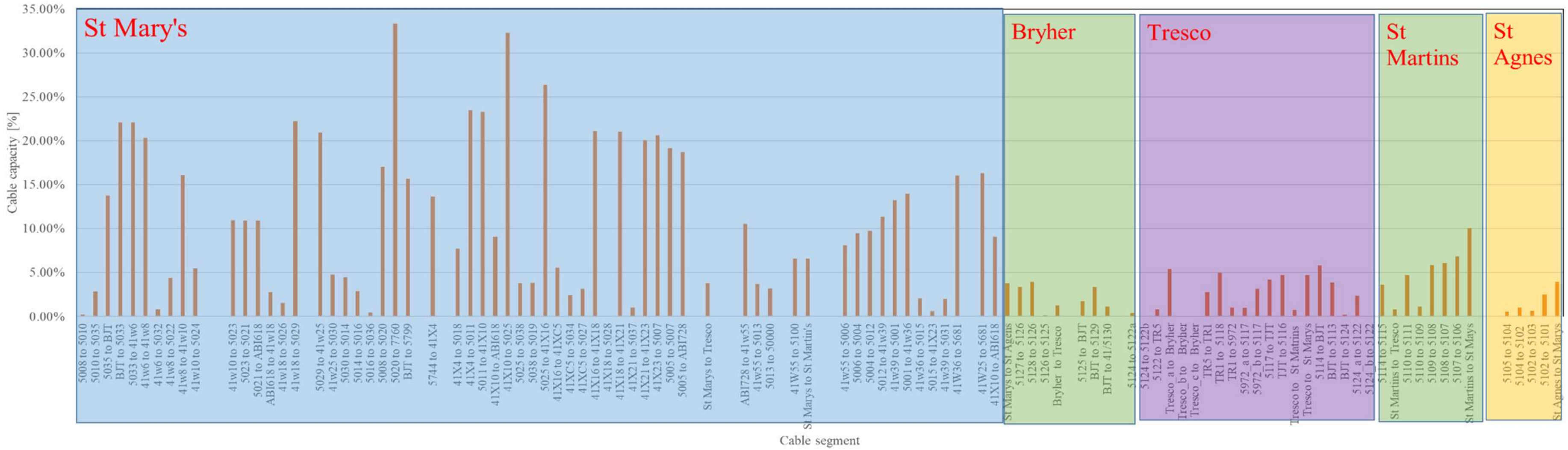

Figure 47 - Cable usage capacity at maximum RE output power scenario 1

For the reliability assessment, it is assumed that most of the houses in all islands have PV roof-top. Depending on the power output from the PV, the power demand from the house can be supplied by PV, PV & utility grid or utility grid. Therefore the load sharing in reliability analysis cannot apply. There is maximum reliability when the PV can supply the entire load and there is a fault in a utility grid. This scenario is considered in reliability assessment. At each load node, they're a step-down transformer and a circuit breaker as in T1.2. Under these assumptions, the failure rate of the load node compared to the utility grid only is shown in Figure 48. The failure rate for each load node is very small when considered the PV at each house and utility grid.

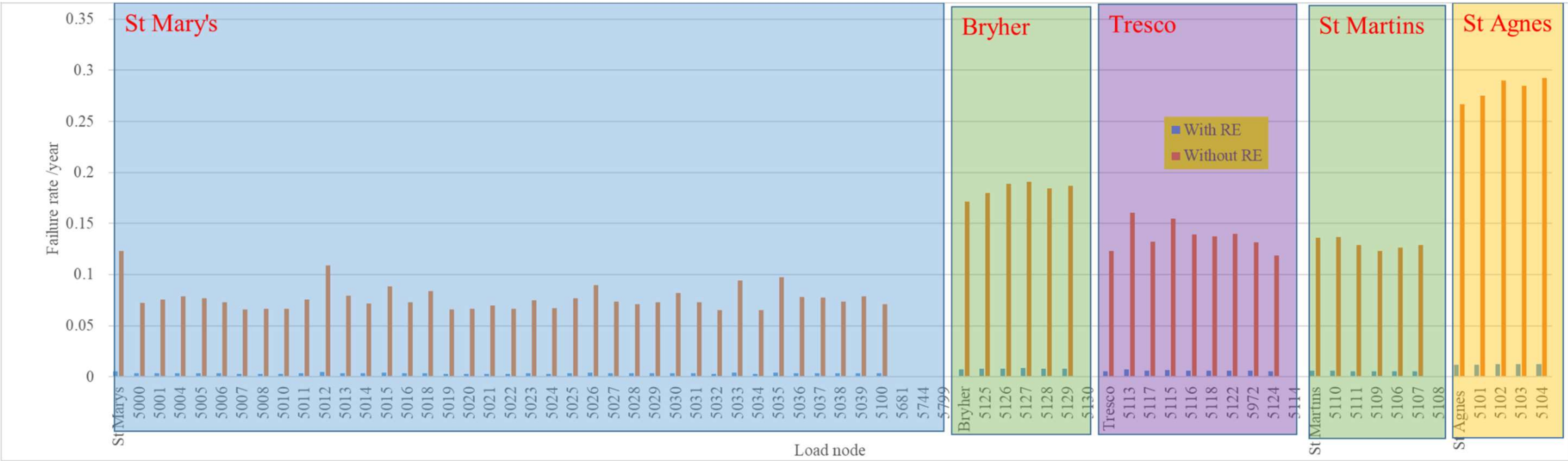

Figure 48 - Load node failure rate/year scenario 1

6.5.2 Renewable Energy assessment Scenario 2

In this scenario, a combination of solar PV and wind turbines is considered. The necessary data for power flow analysis at each scenario, maximum load and maximum RE output is shown in Table 17**Error! Reference source not found.**. The locations of the WTs are shown in

Table 17 - Load and renewable energy power data under Scenario 2

	Scenario 2.1		Scenario 2.2		Scenario 2.2	
	At Max Load	At Max RE	At Max Load	At Max RE	At Max Load	At Max RE
Total Load demand	4.853 MW	2.216 MW	4.853 MW	2.657 MW	4.853 MW	2.657 MW
Roof-top PV output	0 MW	1.157 MW	0 MW	1.15 MW	0 MW	1.15 MW
Ground mounted PV output	0 MW	0.388 MW	0 MW	0.385 MW	0 MW	0.385 MW
Wind Turbine	0.242 MW	1 MW	0.146 MW	1.1 MW	0.194 MW	1.05 MW

For Scenario 2.1, the voltage drop at maximum load and maximum RE output are shown in Figure 49 and Figure 50 respectively. The voltage drop is high at maximum load and reaches to more than 3.5%. At maximum RE output, the maximum voltage drop is -0.7 (negative means the load voltage is higher than the nominal voltage) this is due to excess in generation power.

The cable usage capacity under two conditions, maximum load and maximum RE output power, are shown in Figure 51 and Figure 52. At maximum load, the cable usage capacity is quite high especially at the city centre of St Mary's, nearly 80%.

For Scenario 2.2, the voltage drop at maximum load and maximum RE output are shown in Figure 53 and Figure 54 respectively. The voltage drop is high at maximum load and reaches to more than 3.8%. At maximum RE output, the maximum voltage drop is -0.9%.

The cable usage capacity under two conditions, maximum load and maximum RE output power, are shown in Figure 55 and Figure 56. At maximum load, the cable usage capacity is quite high especially at the city centre of St Mary's, nearly 80%.

For Scenario 2.3, the voltage drop at maximum load and maximum RE output are shown in Figure 57and Figure 58respectively. The voltage drop is high at maximum load and reaches to more than 3.8%. At maximum RE output, the maximum voltage drop is -0.5%.

The cable usage capacity under two conditions, maximum load and maximum RE output power, are shown in Figure 59 and Figure 60. At maximum load, the cable usage capacity is quite high especially at the city centre of St Mary's, nearly 80%.

For the reliability assessment, it assumed that at each load node, they're a step-down transformer and a circuit breaker as in T1.2. Only scenario 2.1 is considered in this report. This is due to all the three sub-scenarios in scenario 2 are the same where all have rooftop solar, ground-mounted PV and WT. Scenario 2.2 has only four big wind turbine at ST Mary's and scenario 2.3 is near as scenario 2.1 expect the power rating of the WT is high at St Mary's. Therefore, the maximum reliability is achieved when considering scenario 2.1 or 2.3 where the maximum number of WTs are installed. Under these assumptions, the failure rate of the load node compared to the utility grid only is shown in Figure 61. The failure rate for each load node is very small compared to the utility grid.

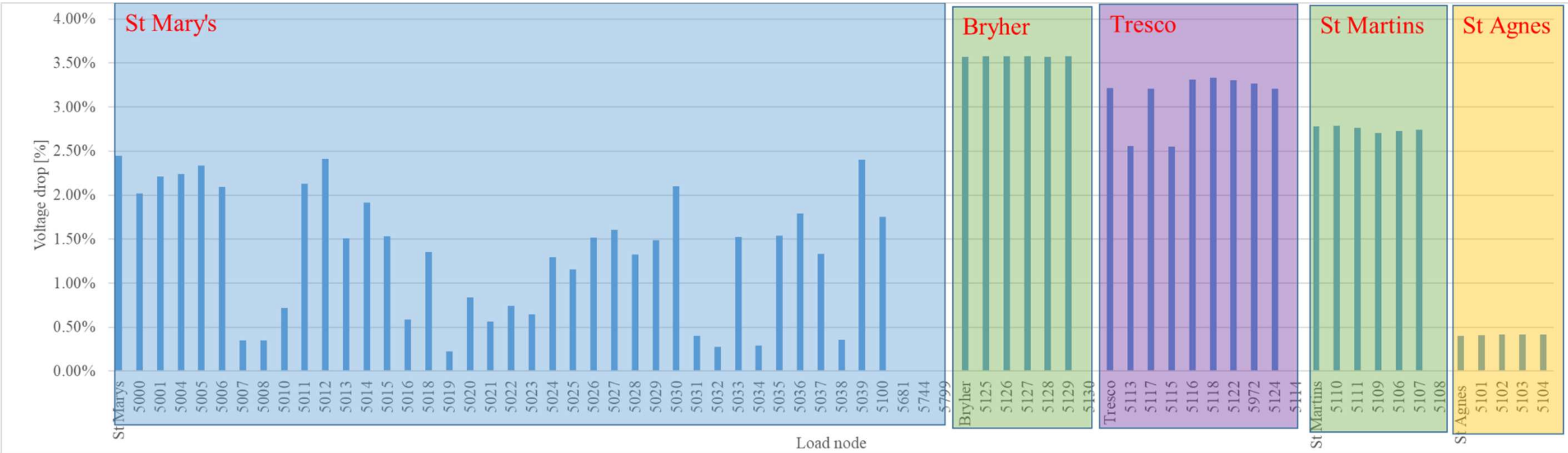

Figure 49 - Load node voltage drop at maximum load scenario 2.1

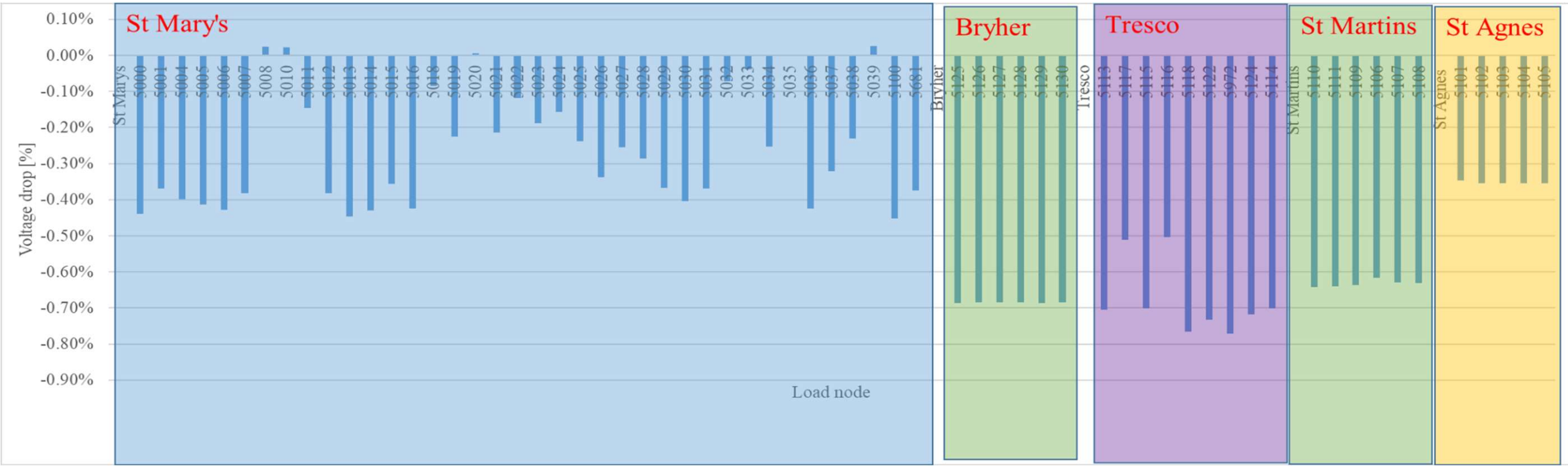

Figure 50 - Load node voltage drop at maximum RE output power scenario 2.1

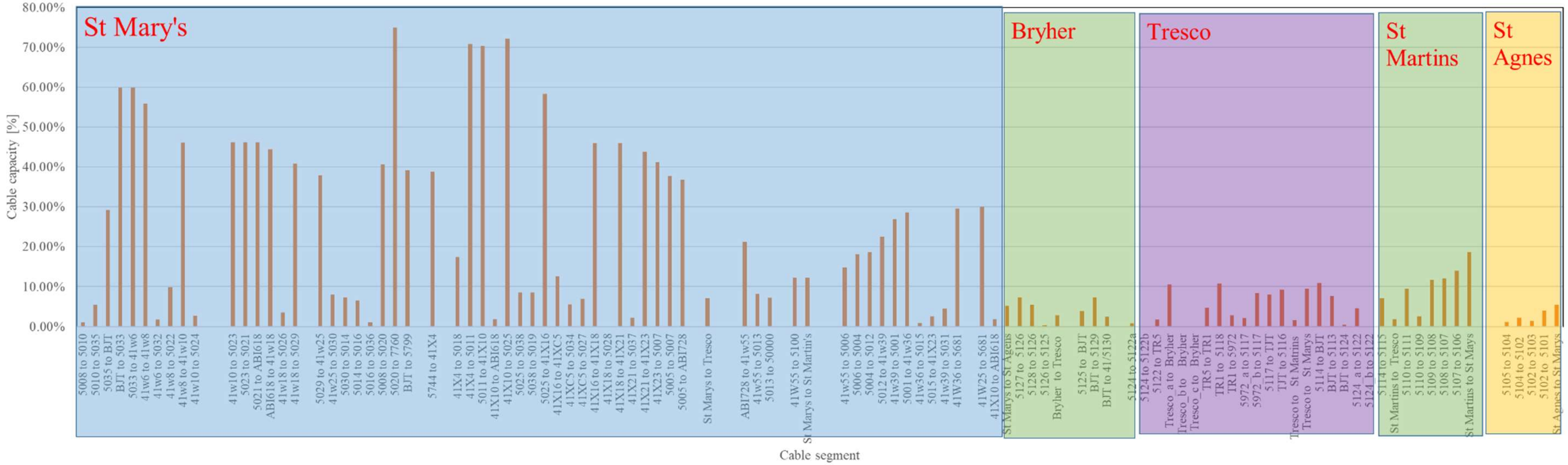

Figure 51 - Cable usage capacity at maximum load scenario 2.1

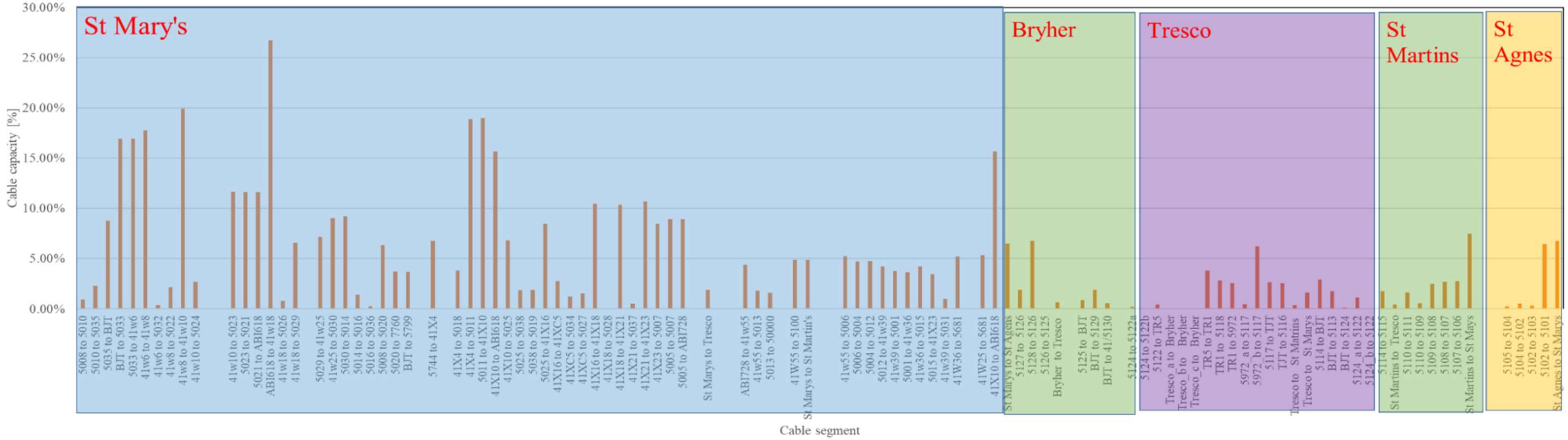

Figure 52 - Cable usage capacity at maximum RE output power scenario 2.1

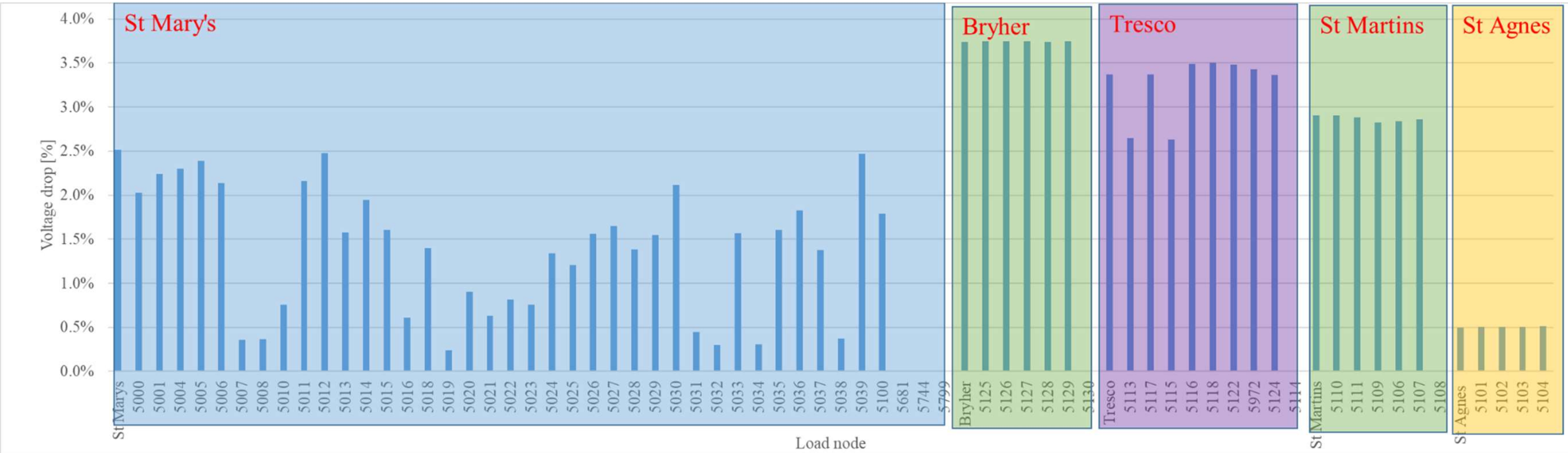

Figure 53 - Load node voltage drop at maximum load scenario 2.2

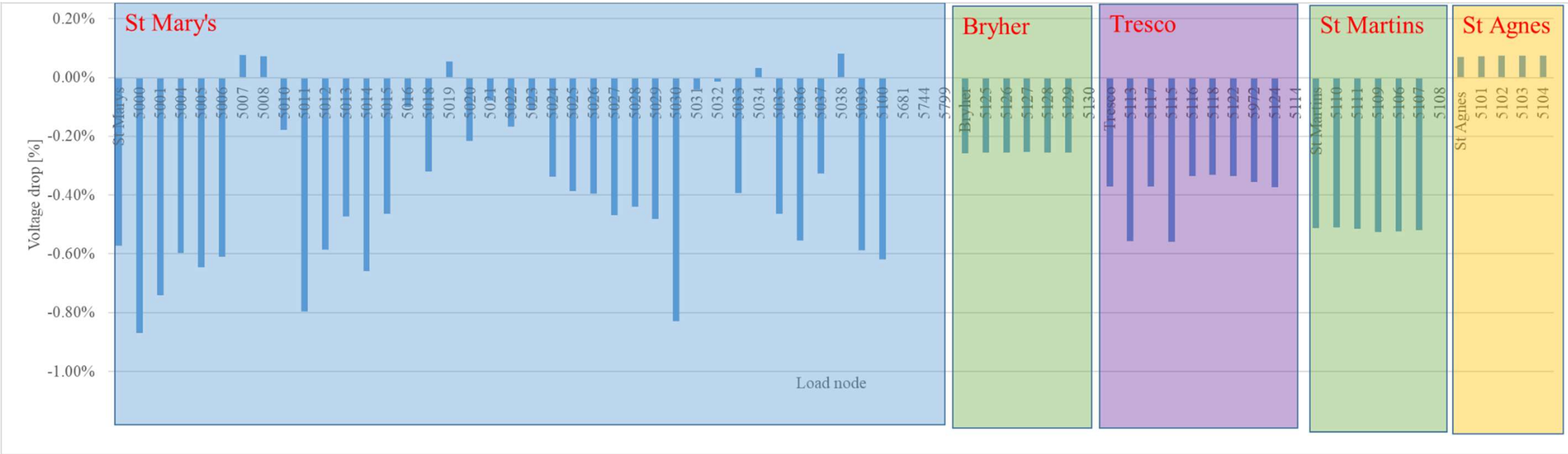

Figure 54 - Load node voltage drop at maximum RE output power scenario 2.2

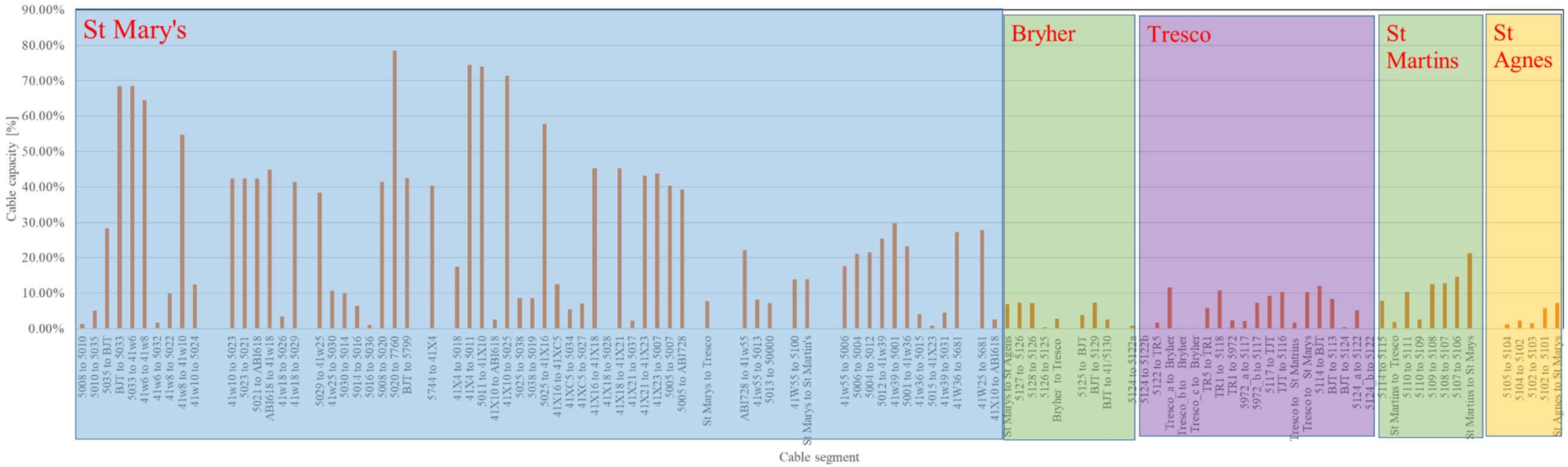

Figure 55 - Cable usage capacity at maximum load scenario 2.2

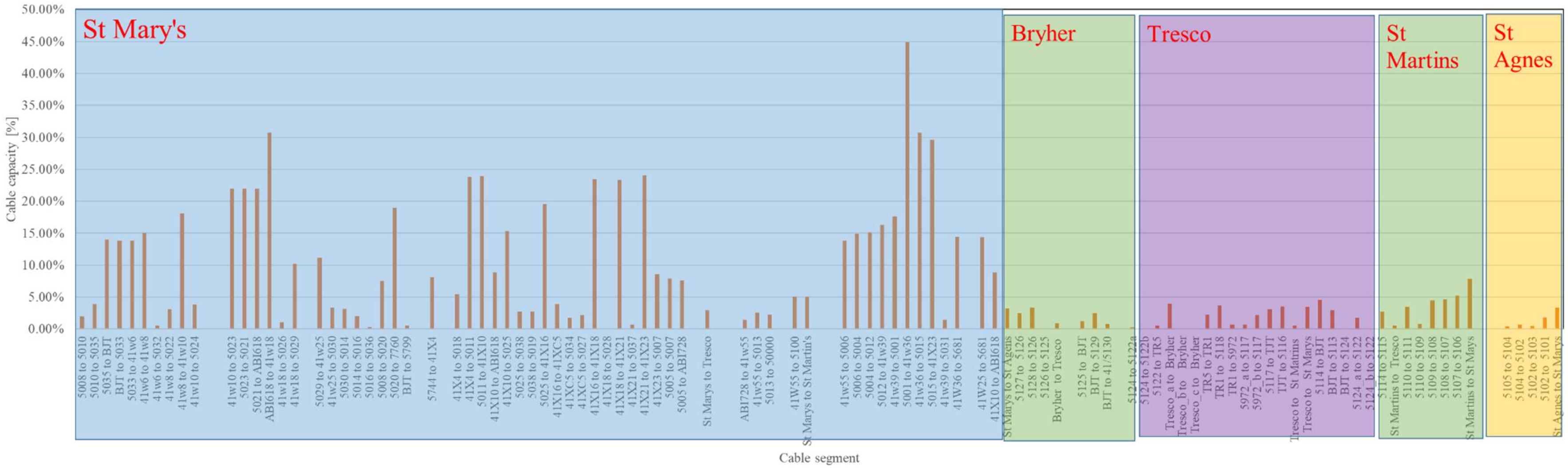

Figure 56 - Cable usage capacity at maximum RE output power scenario 2.2

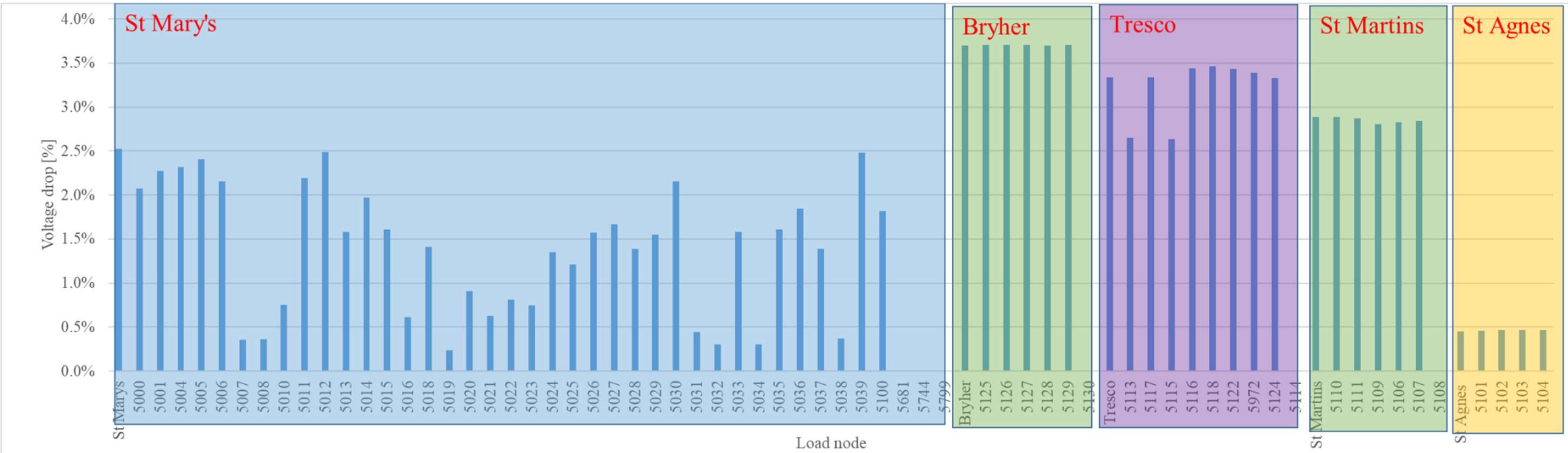

Figure 57 - Load node voltage drop at maximum load scenario 2.3

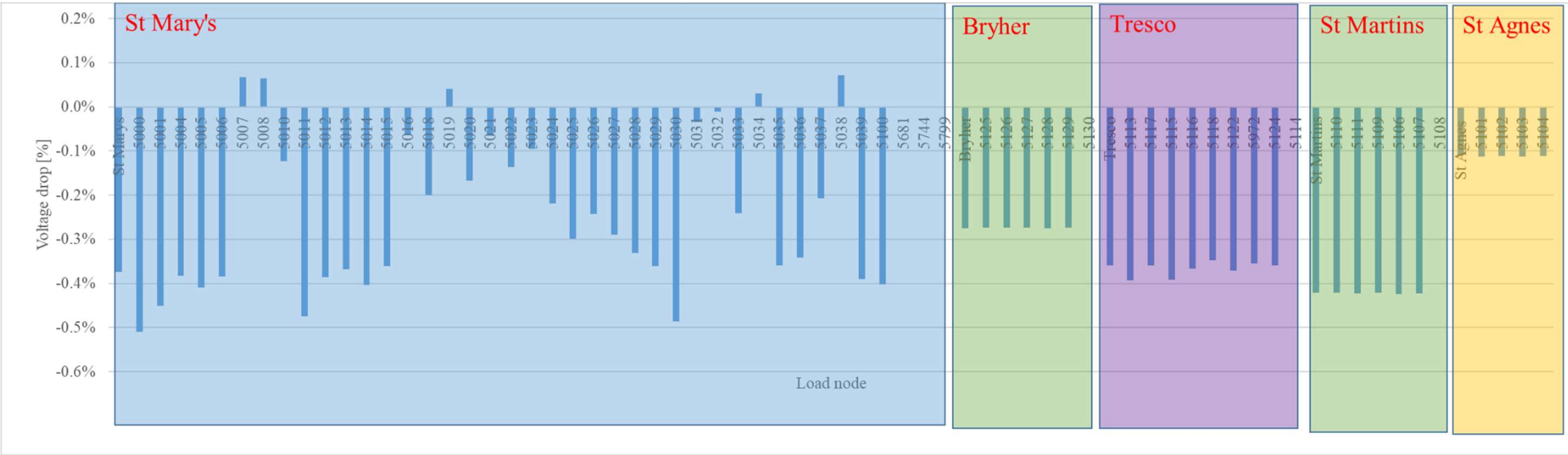

Figure 58 - Load node voltage drop at maximum RE output power scenario 2.3

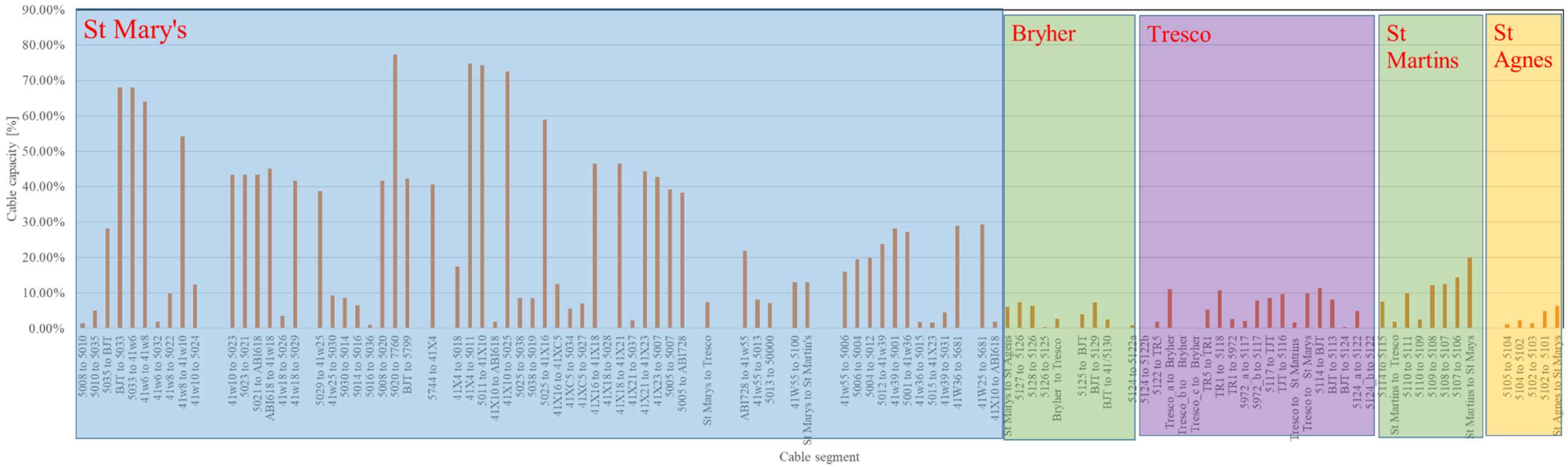

Figure 59 - Cable usage capacity at maximum load scenario 2.3

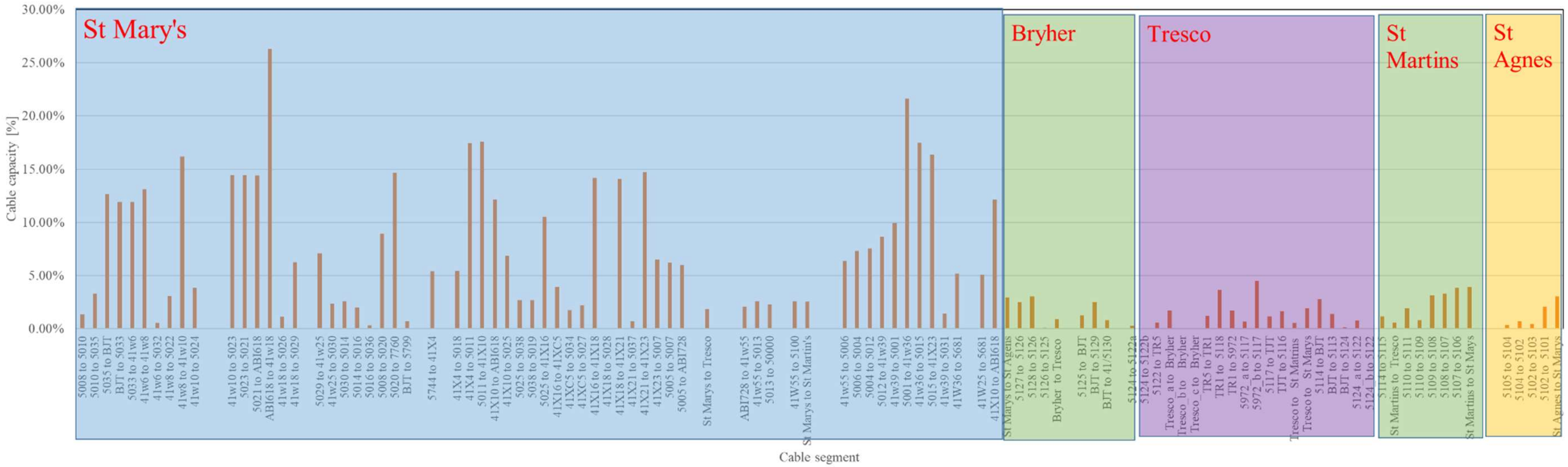

Figure 60 - Cable usage capacity at maximum RE output power scenario 2.3

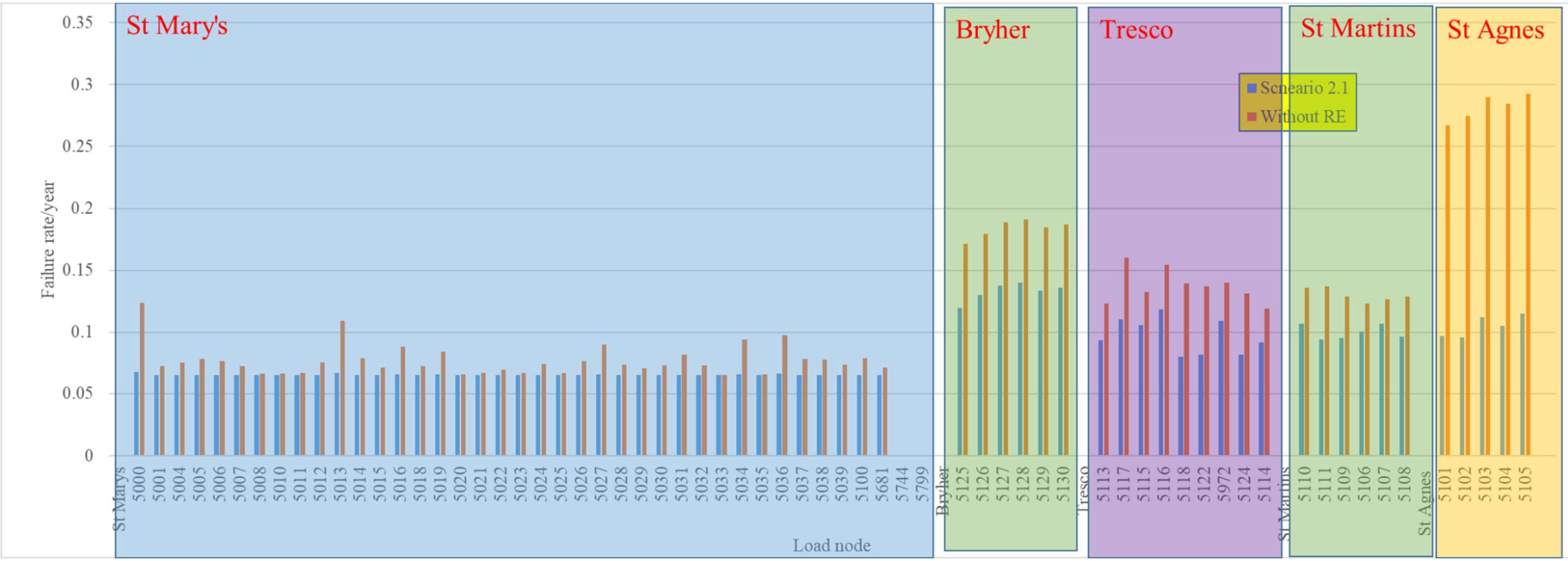

Figure 61 - Load node failure rate/year scenario 2.1

6.5.3 Renewable Energy Load Assessment

The IoS have an aim is to supply 40% of energy demand from renewable energy sources. There are two proposed scenarios. The first one uses PV alone, as shown in Table 18.

Table 18 - Renewable Energy Scenario 1

Solar Installation	**AEP (MWh)**	**% IoS Demand**
Rooftop Solar (1440kW)	1479	7.93
Ground Mounted (480kW)	5979	32.07
Total (1920 kW)	**7458**	**40**

The second scenario is a combination of PV and wind turbines. There are three possible combinations as shown in Table 19.

Table 19 - Renerable Energy Scenario 2

	Energy Scheme	**AEP or Saving (MWh)**	**% IoS Demand**
Scenario 2.1	Efficiency	1849	9.92
	Wind (10*100kW)	4004	21.48
	Rooftop Solar (1440kW)	1479	7.93
	Ground Mounted (480kW)	493	2.64
	Total	**7825**	**41.97**
Scenario 2.2	Efficiency	1849	9.92
	Wind (4*250kW)	3268	17.53
	Rooftop Solar (1440kW)	1479	7.93
	Ground Mounted (480kW)	493	2.64
	Total	**7089**	**38.02**
Scenario 2.3	Efficiency	1849	9.92
	Wind (2*250kW & 5*100kW)	3636	19.50
	Rooftop Solar (1440kW)	1479	7.92
	Ground Mounted (480kW)	493	2.64
	Total	**7457**	**39.98**

6.6 Local Enterprise Capacity Mapping

Table 20 - Capacity Mapping for Local Enterprise

Supplier opportunities	Populating the Value Chain	Capacity Mapping	
		Opportunities for Local Enterprise	Example Businesses
Planning			
- Project Rationale			
- Public Consultation	Broad consultation of residents (& some tourists)		Isles of Scilly Community Venture
- Surveying and Consenting	Planning, ecological and archaeological surveying, and EIA	Local ecologists, or environmental and planning consultants	ONS: 5 Professional, scientific and technical businesses on the IoS, 2,625 in Cornwall. Yell: 7 environmental consultants in West Cornwall plus the Isles of Scilly Wildlife Trust (stakeholder) Yell: No planning consultants on IoS, but at least 6 in West Cornwall (within 50km) Yell: 1 Archaeological consultant in Taunton, & 1 in Bristol
Financing	Capital for GM PV & wind Personal investment for domestic PV Community investment	Community share offer Community energy finance for households/businesses	Example organisations: Isles of Scilly Community Venture Communities for Renewables Community Power Cornwall
Grid Design and Engineering	Integrating demand and supply spatially Integration with mainland interconnector	M&E HV design specialists	Yell: No M&E engineers in Scillies, but at least 3 in wider West Cornwall.
Procurement			
- Generation	Solar PV Wind		
- Storage	Large-scale storage Small-scale storage		

- Interfaces & Services	Voltage and frequency stabilisation		
- Demand Management	Energy efficiency materials DR hardware		
Installation			
- Generation	GM & RM PV – specialist Wind – Specialist Large-scale storage – specialist Small-scale storage – (MCS) electrician	Solar PV/renewable installers	Yell: At least 4 PV in west Cornwall
- Civils	GM PV mountings – generic Wind infrastructure Storage infrastructure	Local engineers Local building trades	ONS: 15 businesses in 'Construction' on the IoS, 3,555 in Cornwall. Yell: At least 3 builders on the Scillies and at least 2 in wider West Cornwall
- Electricals	HV Wires and connections – HV specialist LV wires & connections – generic sparky	Local electricians/M&E for LV work	No specialist HV engineers. Yell: At least 28 electricians in Penzance.
Operation			
- Logistics	Spares inventory	Local storage	ONS: 30 Transport and storage providers in Scillies. Yell: At least 1 storage provider on the Scillies
- Maintenance	Generation – electricians Balance of plant Environmental monitoring	Tradespeople Environmental consultants	Yell: At least 28 electricians in Penzance Yell: At least 4 PV in west Cornwall Yell: 7 environmental consultants in West Cornwall, plus the Isles of Scilly Wildlife Trust (stakeholder)
- Billing	Via energy supplier		

- Management	Co-ordination and facilities management	WP or 3rd party	ONS: 15 Business & Admin support businesses on the IoS, 1,805 in Cornwall.

“Yell” = Yell (2020), “ONS” = ONS (2019).