Mainland Interconnector Capacity Assessment

A report for Wight Community Energy

Final Report for Wight Community Energy

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Customer:

Wight Community Energy

Contact:

Michael Kelly, 1 Frederick Sanger Road,
Guildford GU2 7YD, UK

T: +44 (0) 7581 452 491

E: michael.kelly@ricardo.com

Author:

Michael Kelly, Tim Skelton

Approved by:

Simon Terry

Signed

S.C.Terry

Date:

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Glossary

Abbreviation	Definition
DNO	Distribution Network Operator
SSEN	Scottish & Southern Electricity Networks
NGESO	National Grid Electricity System Operator
LV	Low Voltage

1 Introduction

1.1 Project context

The Isle of Wight has a rich abundance of renewable energy resources including solar, tidal and wind and is therefore well positioned to accelerate the IoW Council's aspirations for a transition towards a cleaner carbon neutral diversified energy mix that will support the island's electrical demand. Although the individual generators have to sell their output via the energy markets managed by the National Energy System Operator, due to their electrical proximity to the island's load, embedded generators on the island will tend to support the local load and export any surplus to the UK mainland via the interconnectors running between the island distribution network and the network on the UK mainland. Where the output from local embedded generation is insufficient to meet the local island demand there will be a net import of energy to the island from the UK mainland via the interconnectors.

There has been a significant increase in renewable generation on the island in the past decade, with over 90 MW of ground mounted solar PV installations receiving a connection to the island's electricity distribution network as so called "embedded" generation.

However, due to the island load profile, the number and capacity of the interconnectors and the intermittent nature of existing local renewable generation, SSEN's obligations is to provide the level of consumer supply security specified in their operating licence and their obligation to provide a firm capacity to the Cowes gas turbine power plant to export to the UK mainland: SSEN have indicated that any additional embedded generating capacity on the island will be subject to periods of curtailment due to SSEN's obligations in respect to the foregoing factors. Alternatively, to have a firm connection new generators may have to fund the significant cost of reinforcing the interconnectors between the island and the UK mainland.

In addition, there is the added complication of the capability of the existing electricity network on the island to accommodate an increase in local generation without some level of local network reinforcement. Given the foregoing the financial case for further development of renewables-based generation on the island is not clear.

Wight Community Energy (WCE) commissioned Ricardo Energy & Environment (Ricardo) to make an assessment of SSEN's position on the operation of the interconnectors that run between the island distribution network to the network on the UK mainland and identify options for changing the management of this infrastructure and/or upgrading the physical infrastructure with a view to establishing a situation that is more attractive to the further development of renewable energy resources on the island.

The results of the assessment undertaken by Ricardo to answer Wight Community Energy's questions are presented in this report.

1.2 Requirements of the engagement

The assessment was to address the following key points.

- To understand what modelling techniques and assumptions SSEN use to assign capacity to the interconnectors and to determine under what conditions the application of constraints on the island's renewable generation become necessary
- To understand what is driving SSEN's approach to the network operational management and network development on the island
- To understand how the Active Network Management system works and in particular the decision-making processes and logic incorporated in the system

It was also important to address the following questions:

- To understand where and how limitations on the network capacity arise and their significance for network operational management
- To establish to the seasonal capacities of the of the interconnectors

2 The Isle of Wight Electricity Distribution Network

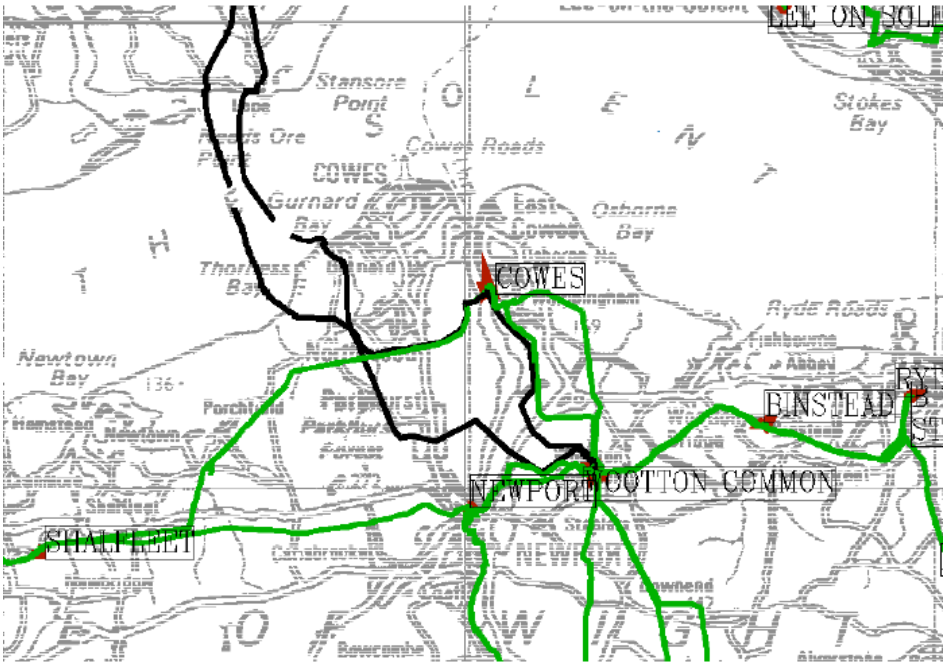
2.1 Network Layout

The Isle of Wight has three 132 kV interconnectors which supply the island's demand throughout the year. A diagram representing the electrical network infrastructure on the Isle of Wight (IoW) is shown in Figure 2-1. This diagram is based on the diagram published by Scottish and Southern Electricity Networks (SSEN), the Distribution Network Operator (DNO) for the Isle of Wight in their Long-Term Development Statement (LTDS) network. Like all distribution networks in the UK, there are four types of electrical substations that are used to distribute electrical power from the national electricity transmission network to consumers in a specific geographical location. These are as follows:

- **Grid Supply Points (GSPs):** These are network substations that provide the connection between the National Electricity Transmission System, owned by National Grid and the distribution network, which is owned by the DNO. GSPs step the voltage down from the transmission network voltage of either 400 kV or 275 kV to the highest distribution network voltage of 132 kV known as the sub-transmission network or EHV network.
- **Bulk Supply Points (BSPs):** These are electrical substations that step the incoming 132 kV voltage down to 33 kV, which is then distributed to different primary substations in the region.
- **Primary Substations:** These are substations which take the incoming 33 kV feeder and steps the voltage down to 11 kV which supplies industrial and residential areas.
- **Secondary Substations:** These are substations which take the incoming 11 kV feeder and step the voltage down to Low Voltage (LV), which will supply residential homes with a standard 230 V incoming single-phase supply.

In Figure 2-1 the black lines represent the 132 kV interconnectors that supply the island's network, with two interconnectors feeding Wootton Common BSP, and the third supplying the Cowes BSP. There are two interconnectors between Wootton Common and Cowes substation to ensure that security of supply is maintained should one of main interconnections go out of service. The green lines represent the 33 kV circuits that supply the primary substations across different locations on the Isle of Wight.

Figure 2-1 Network Infrastructure layout of the Isle of Wight Network at the present time



The DNO heat map, which is publicly available to view on their website, gives an overall estimation of the current level of demand and generation headroom on the network. Currently the two BSPs described above are marked in red, which indicates that there is no generation headroom available on the network.

2.2 Network Capacity

As discussed in the introduction there are two key aspects to establishing network capacity, the capability of the interconnectors linking the island network to the UK mainland network to accommodate additional load and the capability of the local network on the island to accommodate additional load at each point in the network where connection of a new generator is proposed. This section focuses on the capacity of the interconnectors.

For the interconnectors, capacity constraints can occur at either end or on the interconnectors themselves and these various scenarios are considered in the following sections.

2.2.1 Interconnector Constraints – Mainland and Isle of Wight

Constraints on the network can be implemented on the Isle of Wight in each of the following scenarios:

- The loss of service of the 132 kV overhead lines at Fawley substation, which supplies the Isle of Wight.
- The loss of 132 kV interconnectors; and
- The loss of the Super Grid Transformers (SGT) at Fawley substation

Equipment thermal limits are one of the main factors that limit load on networks, and prior to the appearance of embedded generation, networks were designed to accommodate the forecast demand for a defined planning horizon with no active generation and an allowance for defined levels of random equipment failures.

With the arrival of deregulation, Ofgem the regulator and the advent of extensive embedded generation meant that the basis on which the networks were originally designed was no longer valid. In addition, the regulator challenged the network operators to get the most out of their existing assets.

Part of the response to this has been to develop strategies and technologies that allow the network equipment to operate closer to their thermal limits. One of the technological responses is the development of Active Network Management control systems. These systems can be deployed to manage the loading on networks in real time by various load management strategies including constraining the output of embedded generators in response changing network conditions.

2.2.2 Cowes Gas Turbine Power Plant

RWE Generation has a 140 MW firm connection agreement with SSEN for their Open Cycle Gas Turbine at their Cowes Power Plant. From recent data it is understood that the Cowes power plant has had a utilisation of less than 0.5% each year for the last five years. Thus, this connection agreement is a significant contributor to the limitation of interconnector capacity on the Isle of Wight as the agreement capacity is permanently reserved for the Cowes power plant whether the plant is generating or not. It is understood that NG instruct the Cowes power plant to run to counter stability issues that are occasionally experienced on the South Coast section of the national transmission network.

2.2.3 Network reinforcement planning

National Grid Electricity System Operator (NGESO) are planning to install a new Super Grid Transformer (SGT) at the Fawley GSP in 2023. This requirement for network reinforcement was identified after an extensive technical review by SSEN of, amongst other issues, the current constraints on the island's interconnection to the transmission grid, forecast increase in demand on the island, and the increase in embedded generation on the island. After studying the network under peak demand conditions, SSEN reported that the network is forecasted to experience thermal overload under N-2 scenarios. Conversely, under minimum demand conditions and N-2 scenarios, an increase in embedded generation is again forecast to cause thermal overload. The installation of a new SGT in the coming years will resolve the forecasted thermal limitations on the mainland end of the interconnectors and their connection to the transmission network and thereby permit greater utilisation of the full capacity available in the subsea cable.

3 Stakeholder engagement

During the course of the assessment there have been meetings with the following stakeholders.

3.1 SSEN

Scottish & Southern Electricity Networks (SSEN) are the Distribution Network Operator (DNO), who own and maintain the distribution network in their two licences regions: Northern Scotland and Southern England. Three core divisions within SSEN's business area were interviewed to understand what modelling techniques and assumptions are applied to the Isle of Wight network in order to curtail generation export. Other areas of investigation included understanding what is driving SSEN's approach to curtail generation export, and to gain an understanding into how the existing Active Network Management system operates.

3.1.1 Systems Planning Team

The systems planning team at SSEN are responsible for identifying where in the network there is likely to be future or existing thermal and voltage constraints due to future load growth, which could impact on network operation and security. They do this by using established network models in order to run load flow analysis to see the interactions between various load growth scenarios on the network's performance. This allows SSEN and the other DNOs to justify future investment in reinforcement of their network.

3.1.2 Flexible Solutions Team

Connecting new generators to the distribution networks in constrained areas will require reinforcement works to be undertaken with associated increased connection costs and waiting times to connect. DNOs can offer an alternative in the form of flexible connections. This involves acceptance of constraints within the terms of the connection, such as maximum export level or restricting generation export under certain network conditions. Flexible connections can be used as a temporary solution whilst awaiting the completion of the network upgrades or as a permanent alternative to reinforcing the network.

The flexible solutions team at SSEN designed and implemented the Active Network Management system on the Isle of Wight in 2017, which is presented to new generator application requests as a flexible (non-firm) connection offer.

3.1.3 Generation Connections Team

SSEN has a generation connections team that manages new generation connection applications. This involves assessing their applications to ensure they are compliant with the requirements outlined in Engineering Recommendation (EREC) G98 / G99.

The generation capacity will be assessed by the generation connections manager, which involves having discussions with the systems planning and flexible solutions team to establish whether there are any tipping points on the network which triggers reinforcement, and to update the ANM platform with this new generator connection.

3.2 NGESO

National Grid Electricity System Operator (NGESO) are the system operator for Great Britain who are responsible for balancing generation and demand on a second by second basis by moving electricity at high voltages through the national transmission grid. They balance the network by making requests to generators to increase or decrease their active power output from their units, or by asking large customers to control their demand, thereby keeping the network within statutory limits. NGESO are a legally separate company within the National Grid Group.

NGESO has a Short-term operating reserve (STOR) contractual arrangement in place with the East Cowes Open Cycle Gas Turbine Power Plant on the Isle of Wight to provide emergency support services when the transmission grid becomes unstable in the south coast region. At the moment, Ricardo has been unable to arrange a meeting with the right people at NGESO. As this is pending, the objective would be to discuss the following issues:

- What support services does the East Cowes Gas Turbine Power plant provide to the South Coast transmission grid;
- To understand NGESO's concerns about renewable generation utilising the firm capacity when the plant is not operating;
- Is there a possibility that generation or battery storage could provide the same support services to the network; and
- Are NGESO open to considering future scope for a network innovation project to investigate how feasible it is to use renewable generation on the island to support the grid during network stress.

4 Network assumptions and operation

This section presents the key findings on how the current situation with the IoW electricity network is constraining the development of the renewable generation on the island.

4.1 Management of the Isle of Wight network

SSEN use standard network assumptions to manage constraints on the IoW electricity distribution network with everything being planned against the forecast minimum / maximum demand on the island. The IoW distribution network supports customer demand and embedded generation and SSEN use different strategies to manage demand and generation.

Customer Demand: In accordance with the conditions of their operating licence issued by Ofgem, SSEN are required to ensure they are compliant with the applicable network security supply standards defined in Engineering Recommendation P2/6. In this case, SSEN operate the Isle of Wight network to ensure supplies to customers are secure from N-1 upstream failure conditions, which requires that when all three subsea interconnectors are in service, the normal condition, the failure of any one interconnector does not comprise the security of supply to SSEN customers on the island.

Embedded Generation: Whilst SSEN are obliged to offer connection agreements to renewable generating plant there is no general obligation to ensure the availability of the export capacity associated with each connection. Rather the level of security is based on the stipulations of individual connection agreements. In addition, the security of supplies to customers has priority over the export capacity available to embedded generators.

SSEN have indicated that the interconnectors are now running at or close to full capacity due to the combined effects of customer demand, equipment thermal limits, the requirements for ensuring security of supplies to customers, and the requirement to honour the firm export capacity enshrined in the Cowes power plant connection agreement.

In addition, during the summer months, when the average ambient temperature is at a maximum the network capacity is at a minimum. Each of the network elements that make up the Isle of Wight distribution network have a maximum operating temperature, and, in the summer with no load applied each network element is at a higher temperature than it would be under the same conditions in the winter. When electrical current passes through a network element it generates heat internally and the higher the current, the greater the amount of internal heating.

Since the no load starting temperature in the summer is higher it takes less current through each element before reaching its maximum operating temperature compared to in the winter months. This means that the network has less capacity available in summer than in winter, hence SSEN have summer and winter ratings for their equipment and for the network as a whole. Thus, during the summer when PV output peaks the network capacity is at its lowest, and although the summer demand is lower it does not match the increased output of the Solar PV based generation, and this results in SSEN having to constrain generation export to the network more in the summer than in the winter.

4.2 Active Network Management

In order to obtain maximum operational benefit from their existing assets SSEN have developed an Active Network Management (ANM) system. This is a control system that automatically manages the energy export from embedded generation in real time to ensure all the various network equipment limitations, supply security requirements, and connection agreements are respected at all times. Generators signed up to this scheme have non-firm connection agreements which are not favoured by developers as the level of return from an investment in renewable generation is affected not only by the inherent intermittency in output from solar PV based generation but also by intermittency in the availability of export capacity. This results in an increased investment risk and to date only one generator is signed up to the ANM scheme. SSEN's policy is to only to provide non-firm connections manged by the ANM system with minimal reinforcement costs, or require prospective generators who want a firm connection agreement to pay for significant levels of network reinforcement, which has brought investment in major new solar PV generating plant on the island to a standstill.

4.3 Other factors affecting effective network capacity

SSEN clarified that in their network operation of the Isle of Wight, they have no visibility of domestic roof top solar PV installation and do not model them as part of their network management process. Since SSEN load forecasting is in part based on typical customer load profiles that do not take account of the impact of residential roof top installation this may result in an overstatement of the operating capacities required to meet the security of supply requirements which will reduce the capacity available for generators to export to the network.

From a demand perspective, SSEN do not envisage a scenario that requires reinforcement of the island distribution network in the medium term due the low demand on the island. Currently, peak loading on the island is 130 MVA, and with the capacity of each of three interconnectors rated at 100 MVA as a worst-case scenario, there is plenty of demand headroom that can be utilised to accommodate projects for growth in demand.,

Whilst SSEN recognise that it is possible to envisage growth in generator connections that would require additional interconnector capacity, if the prohibitive cost of installing a new interconnector were passed on to developers looking to invest in renewable generating plant this would most likely make such investment financially unviable. The cost to install a new interconnector is estimated to be in the region of £36m to £42m.

Current Ofgem regulations are driving SSEN towards offering a flexible solution to investors in additional embedded generation based on getting more out of their existing assets. As a result, SSEN are not looking at future investments in new large-scale infrastructure development. Rather, SSEN are in the process of investigating new advanced ways to get more capacity from existing assets via the ANM scheme. Currently SSEN believe this is a viable approach to resolving network constraint issues in the medium term.

4.4 Cowes power plant

A number of attempts have been made to secure a meeting with the relevant staff in NGESO with the objective of establishing and understanding NG's requirements for the operation of the Cowes gas turbines and to explore the possibility of replacing the gas turbines with a combined renewable generation and an energy storage solution that could act as a replacement for the GTs. A response is still pending from our last enquiry to NG on this matter.

5 Findings

This project, Mainland Interconnector Capacity Assessment, has found that there are several different factors that are embedded into SSEN's network modelling techniques and assumptions that leads to the allocation and curtailment of generation export on the Isle of Wight distribution network.

SSEN's planning and connection processes are focused on ensuring compliance with their licence conditions and these require them to maintain defined levels of network security for current and future conditions. This means that under minimum and maximum demand conditions, the interconnection to the UK mainland is now at its thermal capacity limit under N-1 scenarios. This is true for the low demand conditions because at this time output from renewable generation on the island is high.

The existing ANM set up is designed to allocate capacity dynamically to generators as it becomes available. A benefit of this approach is that generators avoid potentially high network reinforcement costs. SSEN have recognised that the cost to connect to the ANM platform is a major barrier, which could explain the very low uptake of a non-firm connection agreements mediated by the ANM system since it went live in 2017. To make a connection mediated by the ANM system more attractive SSEN have made a significant reduction in the cost to generators of using the ANM system. At the moment there is virtually no up-take of non-firm connection agreements mediated by the ANM system and SSEN have no motivation to increase the capacity of the interconnectors between the IoW and the UK mainland with the net result that there is little interest in investing in further large scale solar PV plant on the island.

5.1 Recommendations and next steps

The next steps following this project could include:

- **Engage stakeholders in collaboration and best practice:** A key conclusion is that collaboration with key stakeholders on the Isle of Wight and SSEN will help ensure that the IoW's aspirations to work to a zero carbon position for electricity on the IoW is properly understood and ideally supported by SSEN.
- **Propose new innovate ways with SSEN:** Maintain dialogue with SSEN about their future plans to manage the Isle of Wight network, and the possibility of investing in future network innovation projects and new infrastructure to provide capacity to support the uptake of investment in renewable generation on the island. This should include definition of control schemes that allow utilisation of energy storage to supplement existing connection agreements without exceeding the permitted levels of generation.
- **Consideration for renewable and storage:** Investigate the options with NGESO for using renewable generation and storage to support the transmission grid in events when network stability issues and/or multiplexing the firm capacity between renewable and gas turbine plant. A future innovation project may also be appropriate.
- **RWE Firm Connection Agreement:** Develop a full understanding of the legal status of the firm connection agreement held by RWE and how the capacity might be recovered or at least utilised to support renewable generation. Discussions with RWE may be appropriate although they have no obligation to engage in such discussions.

Appendices

The appendices are as follows:

A1 SSEN Meeting 1

Date:	**Friday, 29 January 2021**
Time:	14:00-15:00
Location:	Microsoft Teams
Attendees:	John Smart – SSEN, Head of Systems Planning Engineers Will Monnaie – SSEN, Network Engineer Michael Kelly – REE (Ricardo Energy & Environment) Tim Skelton – REE (Ricardo Energy & Environment)
Apologies:	Mark OConnor – Connection Manager (unable to attend)

No	Agenda Item	Action
1.	**Purpose of the session**	
	To understand what modelling techniques and assumptions SSEN use to assign capacity and constrain renewable generation on the IoW	
	To understand what is driving SSEN's approach in the network operational management and network development on the island	
	To understand how the Active Network Management scheme works	
2.	**Interconnectors**	
2.1	**Management of the IoW distribution network – what assumptions do SSEN make for managing the network in the summer when demand is low and local PV generation is high?**	
	Two ways to look at the network: 1. The first is from the perspective of demand where SSEN have to ensure they are compliant with the security supply standards defined in their operating license, where the N-1 criteria requires that when all three interconnectors are in service, the failure of any one interconnector does not result in any loss of supply to SSEN customers on the island, and; 2. Secondly from the perspective of generation where the security of export is based on the connection agreements rather than any specific license requirements.	
	Whilst early on firm connections were available today most new connections are based on a non-firm arrangement that can be constrained by SSEN, via SSEN's ANM (active network management) system, according to network conditions. In addition, firm connections often require network reinforcement, meaning that the costs for a renewable generation model for small to medium sized installations are financially unattractive.	
	SSEN also advised that there were a number of network constraints where the interconnectors joined the mainland network.	
	Generation connections are manged by Mark OConnor, and he may have a more informed view on the scope for further development of renewable generation on the IoW (Note – REE have reached out to Mark but have had no response as of yet)	
	In relation to generation constraints in the summer, SSEN explained that network ratings on the interconnectors are much higher in winter than in summer. Thus, in the summer when the PV solar plant output peaks the network capacity is at its lowest and	

notwithstanding the lower demand in the summer this results in SSEN having to constrain generation in the summer. Post Meeting Note: there was no discussion of where these constraints occurred within the IoW network or on the interconnectors, or in the mainland network, which will be a point for further consideration.

SSEN further advised that they have no visibility of the roof top single phase PV solar installations and do not model them as part of their network management process. In addition, as a consequence of the increase in PV solar installations the period of minimum demand on clear summer days is been shifted from early evening to mid-afternoon.

2.2 **Cowes Power Plant – What is the current situation with the 140 MW GT power plant on the island and how does this affect the capacity available on the interconnectors?**

The 140 MW Cowes GT (gas turbine) power plant connection agreement was established many years before the advent of renewable generation connections to the IoW distribution network. This is a guaranteed firm connection with no constraints via the interconnectors. The GT plant can provide various types of network support including frequency support, although records show that the plant only runs for around less than 0.5% of the year. However, there is a concern that if the firm capacity assigned to the Cowes plant is utilised by renewable generation when the Cowes plant is not required to run there may be a reduced impact on the network from the Cowes plant if the renewable generation is constrained to allow the Cowes generation to come on line in its place.

3. Active Network Management

SSEN were asked if they could provide some background on the set up and operation of SSEN's ANM system. In addition, SSEN were asked if they could explain their strategy for deploying the ANM scheme when connecting new generation to the IoW distribution network

The ANM system provides SSEN with the capability to directly constrain generating plant according to network loading conditions. Early connections to the IoW distribution network were granted on the basis of firm connections with little or no requirement for reinforcement. Following significant growth in the generation connected to the IoW distribution network there is congestion at many points across the network and significant network reinforcement would be required to obtain a firm connection agreement. The cost of such reinforcement rests with the contractor requesting the connection and the cost of this reinforcement makes new generation financially unattractive. A lower cost alternative is to obtain a non-firm connection without providing network reinforcement where SSEN can constrain the output of the plant, via the ANM system, according to the conditions on the network. However, there is still a significant cost associated with an ANM brokered connection and uptake has been low. Currently SSEN are reconsidering their ANM pricing strategy.

SSEN have an ANM management group, who are better placed to answer questions on voltage level for ANM managed connection, and maybe cost related questions.

In terms of applying constraints and to be fair to earlier investors / connections SSEN operate a last on first off policy. With the current level of connections there is a need to provide projections indicating the annual connection time for new connections as they are reaching a position where new connections can only generate when other generators are disconnected from the IoW distribution network.

4. Anticipated growth in Network Load and Generation

REE asked what are SSEN's plans for accommodating load growth on the IoW through to 2030. In addition, REE requested the most recent average daily load profiles for summer and winter for the island and for the interconnectors, as well as details of the size and mix of renewable generation capacity on the island.

The latest capacity on the network will be on the latest Long-Term Development Statement (LTDS), which will contain peak demands and forecast load growth going forward.

SSEN are currently developing an Electricity Capacity Register due to be published in July 21, which will give visibility on the generation levels of the network. It will look at forecasts of demand and generation over a range of likely scenarios.

	From a demand perspective including meeting the interconnector N-1 requirement, SSEN do not anticipate any requirement for reinforcement in the medium term. Whilst it is possible to envisage a generator connection growth that would require additional interconnector capacity the prohibitive cost of doing this would make current generating scenarios financially unworkable.
	The peak load on the island is around 130 MVA and the capacity of each of the three interconnectors is around 100 MVA, so SSEN believe it is unlikely that reinforcement will be driven by demand growth.
	Developers finance models means that it would not be economically viable to pay for generation reinforcement costs.
	£18m was recently paid just to replace a section of the existing interconnection.
	£20m costs may be needed to provide a new subsea interconnector cable.
	SSEN are not aware of the network model that is being developed by Newcastle University.

A2 SSEN Meeting 2

Date:	**Friday, 29 January 2021**
Time:	09:00-10:00
Location:	Microsoft Teams
Attendees:	Alex Howison – Flexible Solutions Manager Michael Kelly – REE (Ricardo Energy & Environment) Tim Skelton – REE (Ricardo Energy & Environment)
Apologies:	

No	Agenda Item	Action
1.	**Purpose of the session**	
	To understand what modelling techniques and assumptions SSEN use to assign capacity and constrain renewable generation on the IoW	
	To understand what is driving SSEN's approach in the network operational management and network development on the island	
	To understand how the Active Network Management scheme works	
2.	**Interconnectors**	
2.1	**Management of the IoW distribution network – what assumptions do SSEN make for managing the network in the summer when demand is low and local PV generation is high?** **Can we establish the nature of those constraints that limit the power flows across the interconnectors and their significance on the network?**	
	SSEN use standard network assumptions to manage constraints on the network with everything being planned on minimum / maximum demand on the island. SSEN highlighted that there are some DG connections that are not constrained and have an existing firm connection, which was presumably agreed some time ago. SSEN mentioned that there are 5 generators connected to the Distributed Generation Automatic Disconnection Scheme (DCAD), which is one of the existing intertrip schemes that monitors the 132kV network on the IoW and automatically disconnects generation when it detects certain network conditions; for example, when the Cowes power plant is exporting and the loss of the 132kV cable between Fawley and Wootton Common. The ANM scheme was introduced to address the additional capacity that could be used on the island and has real time monitoring in place at the 132kV circuits. SSEN could not indicate what are the most significant constraints on the island, but mentioned the different factors which can lead to a constraint, such as loss of service of 132kV OHLs at Fawley substation to the interconnectors, the interconnectors themselves and the Super Grid Transformers (SGT) at Fawley. SSEN did mention that the constraints are mainly caused by exceeding the recommended thermal limits of the equipment, and the ANM scheme is largely focused at reducing thermal constraints of their equipment rather than focussing on voltage control.	

The ANM scheme is based on code algorithms and is automated, where SSEN mentioned that the scheme curtails generators export according to the location of constraints on the network. The ANM issues set points based on real time loading. For example, SSEN mentioned to Ricardo that if you have 3 x 10 MW generators on the scheme, then the set points used will shave off 5 MW using the last in first out policy. The ANM will then move up the stack and constrain generation further in order to reduce thermal constraints, which can cause equipment and cables to overheat.

SSEN mentioned that there has not been a big uptake on accessing the ANM scheme since it was established in 2017. Cost remains the biggest barrier. SSEN mentioned that the ANM scheme is a decentralised network, and they plan to move towards a more centralised ANM system. Biggest challenges going forward as stated by SSEN are the COMMs and security issues.

2.2 **Cowes Power Plant – What is the current situation with the 140 MW GT power plant on the island and how does this affect the capacity available on the interconnectors?**
How does SSEN manage the firm connection when the GT power plant is not in operation?
What would happen if the Cowes GT plant was decommissioned tomorrow?

SSEN mentioned to Ricardo that they do not manage the firm connection as this belongs to the Cowes power plant. It is a fit and forgot in the case for SSEN. If the plant was removed from the network tomorrow, then there would be a period of time to make sure that the capacity has been released back to the network; this involves having discussions with RWE Generation. Any generation that is first in the stack would get access to the capacity first. However, the connection agreement with RWE would still be in place, and it would be up to them to decide what they do with this firm capacity. SSEN mentioned that they cannot reclaim capacity that is not theirs. There is the possibility that RWE could share some of their firm capacity with other generators. SSEN reminded Ricardo at the meeting that WCE had an arrangement in that past with RWE for access to spare capacity during an outage situation on the island.

3. Active Network Management

SSEN were asked if they could provide some background on the set up and operation of SSEN's ANM system. In addition, SSEN were asked if they could explain their strategy for deploying the ANM scheme when connecting new generation to the IoW distribution network.
In particular:

- **What is the time basis for activation?**
- **What signals trigger the imposition of constraints?**

SSEN mentioned to Ricardo that the network is monitored in real time and the time basis for activation is usually around 3 seconds but SSEN are working on getting it lower than this. Real time data is collected, and thermal and threshold limits are applied and are embedded into the ANM system, which allows the system to perform calculations to determine what response is needed. A calculation is then done to determine which generators should be constrained and the signals are sent to the generators directly. The addition of the ANM scheme does not add to the connection agreement timescales for generators. SSEN mentioned that they would carry out a curtailment assessment which is then provided to the generation developer to inform them on the amount of curtailment they would receive throughout the year, which is crucial for initial investment and future revenue streams.

The algorithms embedded within the ANM system are used to calculate when constraints should be imposed, and they are automated. The Systems Operators in the control room can observe the operation of the ANM system but can only interact with it if it is reporting an error.

SSEN mentioned that they do not guarantee a certain level of export through the ANM scheme. Generators who agree to go on the scheme are accepting constraints, but crucially are avoiding costs. The ANM scheme is continually evolving. From 2023-2024, SSEN plan to move towards a more centralised ANM system, compared to the current decentralised IoW network they have at the moment.

In summary, the ANM system is continually evolving and currently includes real time network analysis and algorithms that will automatically constrain plant under the ANM

	control according to a ‘priority stack’ which is based on LIFO policy. SSEN highlighted Ricardo points that the costs of engaging with the ANM system has to be considerably reduced from SSENs initial investment offer, which could explain why there is only one generator connected to the ANM system on IoW.
4.	**Anticipated growth in Network Load and Generation**
	The cost to replace to install a new interconnector is somewhere in the region of £36m to £42m.
	SSEN mentioned that the ANM system is evolving and they are looking to update their servers.
	The new ANM system has real time low flow analysis supported by state estimation.

A3 SSEN Meeting 3

Date:	**Friday, 29 January 2021**
Time:	09:00-10:00
Location:	Microsoft Teams
Attendees:	Alex Howison – Flexible Solutions Manager Gary Huskinson – Flexible Solution Manager Rhys Penman - Flexible Solutions Manager Michael Kelly – REE (Ricardo Energy & Environment) Tim Skelton – REE (Ricardo Energy & Environment)
Apologies:	

No	Agenda Item	Action
1.	**Purpose of the session**	
	To understand what modelling techniques and assumptions SSEN use to assign capacity and constrain renewable generation on the IoW	
	To understand what is driving SSEN's approach in the network operational management and network development on the island	
	To understand how the Active Network Management scheme works	
2.	**Interconnectors**	
2.1	**Ricardo asked for guidance on how the ANM system works on the Isle of Wight, and in particular the following:** • **On what basis does the ANM system determine when and where constraints are applied to renewable generation?** • **What signals trigger the imposition of constraint?** • **What are the main points on the IoW where operating conditions generate constraints?** • **What are the specific conditions on the interconnectors that trigger constraints?** • **Clarification on how the ANM system handles the 140 MW firm connection?** • **Is their documentation on the ANM system that SSEN could share with Ricardo?**	
	Monitoring and Constraint Instructions SSEN explained that the ANM system does not identify constraints, rather these are identified during the network analysis process carried out by the SSEN systems planning team for new connection applications. If the generator proceeds with the new connection on the basis of a non-firm connection managed by the ANM system, the ANM system is updated with revised monitoring arrangements and constraint instructions to assure the integrity of the distribution network following connection of the new generating plant. . SSEN explained that currently the ANM system receives real time monitoring data on a total of five circuits to identify potential overload situations at three critical points in the distribution network associated with the IoW. If an overload condition is detected the ANM system will issue proportionate output reduction signals to the associated generation in	

accordance with the SSEN LIFO (last in first out) policy for generator output curtailment. If the likelihood of overload condition developing reduces the level of curtailment is correspondingly reduced.

SSEN noted that their DEGAD (Distributed Generation Auto-disconnect) system was favoured by a number of generators on the IoW possibly due to the ANM connection cost, but this was no longer an option for new generator connections. The DEGAD system disconnects generators in response to fault conditions being detected on the distribution network or to planned outage work on the network. Unlike the ANM system which provides a proportionate curtailment of plant output the DEGAD system triggers a complete disconnection of the plant.

SSEN advised that potential overload conditions were calculated after subtracting the Cowes firm 140 MW connection from the available capacity. SSEN further explained that they understand that NG require the Cowes plant to counter instabilities that sometimes arose in the South Coast section of the, national transmission grid and that NG believe they would not see as much beneficial impact on network stability if the Cowes plant simply replaced renewable generation (ignoring for a moment the firm nature of the Cowes connection agreement). SSEN confirmed that they were trying to find a contact at NG who was prepared to explain NGs thinking on this to Ricardo.

Whilst SSEN thought that until such time as RWE stopped paying the annual fee associated with their firm connection agreement, they would retain the right to the associated 140 MW of firm connection capacity. Post Meeting Note: Ricardo understand that this is not a definitive understanding and further efforts may be warranted to properly understand the contractual status of this firm connection should the Cowes plant be permanently decommissioned.

SSEN also mentioned that a larger ANM system was planned for the South Coast transmission network that will operate on N-3 security condition and this may require the application of constraints to generation on the IoW.

From a demand perspective, SSEN stated that there is sufficient head room in the current interconnector capacity to accommodate the projected growth in demand over the next 30 years i.e. there will be no requirement for investment in additional interconnector capacity for the next 30 years.

A4 SSEN Meeting 4

Date:	**Friday, 29 January 2021**
Time:	13:00-14:00
Location:	Microsoft Teams
Attendees:	Alex Howison – Flexible Solutions Manager Mark OConnor – Generator Connections Manager Michael Kelly – REE (Ricardo Energy & Environment) Tim Skelton – REE (Ricardo Energy & Environment)
Apologies:	

No	Agenda Item	Action
1.	**Purpose of the session**	
	To understand what modelling techniques and assumptions SSEN use to assign capacity and constrain renewable generation on the IoW	
	To understand what is driving SSEN's approach in the network operational management and network development on the island	
	To understand how the Active Network Management scheme works	
2.	**Generation connection**	
2.1	**Ricardo asked for guidance on the future uptake of embedded generation on the island, and in particular the following:** • **On what basis is their scope for further uptake of renewable generation on the IoW?** • **To advise on the generation connection process and how SSEN assesses new generation capacity on the network?** • **To what extent are DNOs obliged to invest in network infrastructure at higher voltage level to allow for growth in embedded generation? Do generators only pay reinforcement at the point of connection and one voltage level up?**	
	SSEN stated to Ricardo that they try to get generation connected to achieve their net zero obligations. On the IoW, there is a lot of green energy potential, but the network is at it limits. The Ofgem regulations are driving SSEN towards a more flexible solutions approach. For this reason, SSEN are not looking at major infrastructure investments. SSEN mentioned that they provide generators the data to work out their probability of curtailment, but SSEN / DNOs are now offering to do it themselves as part of a new service going forward.	

Currently the ANM platform has about 44.5 MW of capacity available to utilise. SSEN are looking at more advanced ways to seek out more capacity from the ANM platform, which means pushing the assets even further. SSEN highlighted that the current ANM setup is a good solution over the next few years.

SSEN highlighted that there is a South West Operational Tripping scheme underway in coordination between WPD and NGESO as part of a whole systems approach. This is a national grid requirement to get more embedded generators exporting to the network in an area where the network is not designed to cope with the surge in generation connection. Jan-Feb 2022 is when the system is expected to go live, which will operate under N-3 conditions.

SSEN explained the process for getting generators connected to the network. They assess whether there are any tipping points on the network from the new generation capacity and what triggers reinforcement. This information is then given to the ANM platform to explain the conditions for connection. The customer will have 5 days to consider their options, with no response being regarded by SSEN that they will go for full network reinforcement option

SSEN explained the process for charging for future uptake in both demand and generation. Under Ofgem price controls, SSEN are not allowed to invest ahead of schedule but only when there is a direct surge in demand which exceeds the capacity of their equipment through new connections. Any new connections that trigger reinforcement will be paid in full or as a proportion of total costs, which applies to generator as well. The next price control may change the way DNOs charge for reinforcement, but this is subject to review by Ofgem.

SSEN highlighted that there are security and minimum standards that they are compelled under their licence condition to comply with in the context of demand. In contrast, DNOs do not have the same security standards for generation. This is more of an Ofgem related question and part of their future policy.

A5 Active Network Management

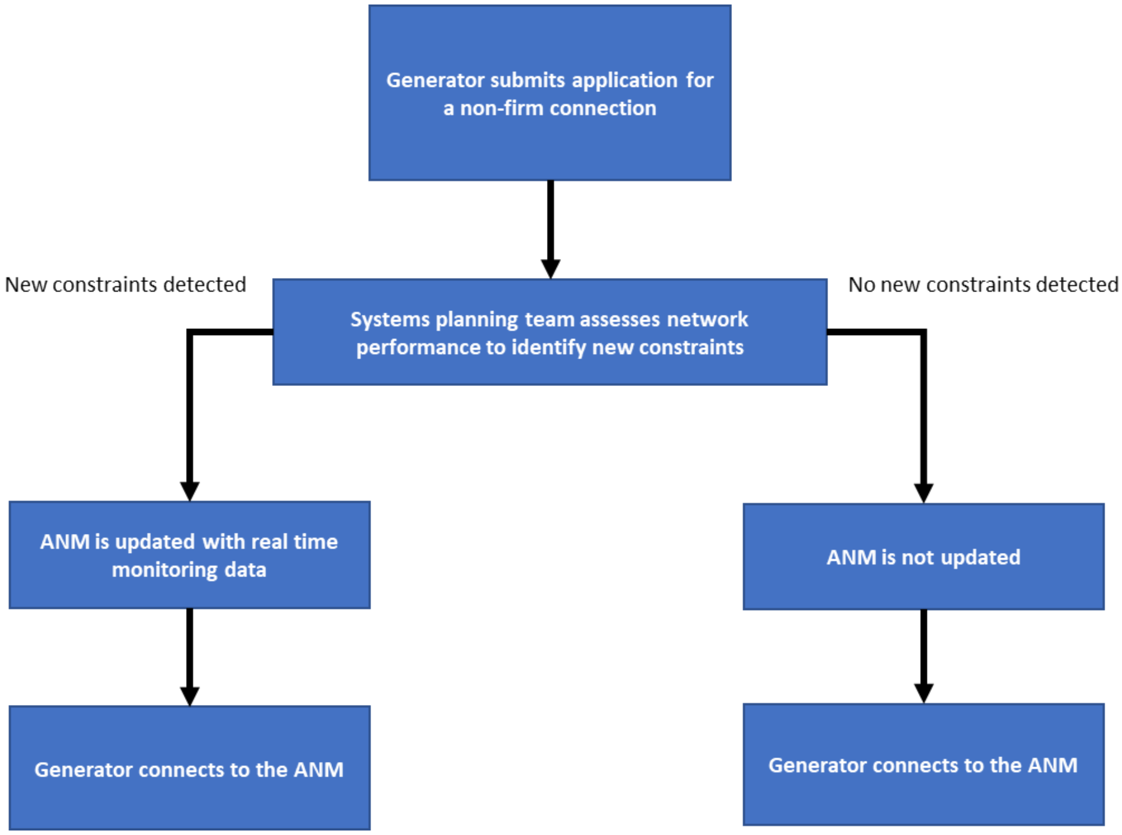
Since SSEN are actively developing their ANM system this more detailed appraisal of their current system has been included.

In areas where there are multiple constraints affecting a number of customers over a long period, an Active Network Management (ANM) system will be implemented by the DNO. ANM is the process of using control systems to manage the real time output of distributed generation in areas where the network is at capacity. The ANM system continually monitors all of the constraints at critical areas of the Isle of Wight network and allocates a maximum amount of capacity available for customers to export under certain network conditions based on the date their connection was accepted. This ensures that network equipment remains within predefined limits, thereby solving network constraints issues, freeing up spare capacity to export and avoiding paying for network reinforcement.

SSEN's flexible solutions team, which manages the ANM platform on the Isle of Wight, explained the steps that are undertaking to accommodate new generator connection applications via the ANM platform. This is captured in the text and flow diagram below.

- **Generator requests a connection:** The generator developer submits an application to SSEN as part of a formal connection application and decides to accept a non-firm connection offer.
- **SSEN identify any tipping points on the network:** The systems planning team at SSEN will use the information provided by the generator to identify any potential tipping points at the critical areas of the Isle of Wight network. This is to ensure that new capacity onto the network does not cause thermal and voltage constraints and overloading of their equipment. After initial investigation from power flow studies on the network, SSEN will recommend a maximum amount of generation export without requiring network reinforcement, which will then be communicated to the ANM platform.
- **ANM algorithm is updated:** The systems planning team communicates their conclusions to the flexible solutions team, who then update the ANM platform with new revised real time monitoring arrangements and constraint instructions to ensure that the integrity of the distribution network is maintained.

Figure 5-1 ANM process for accommodating new generation connections onto the Isle of Wight network



SSEN mentioned that real time monitoring data is gathered from a total of five circuits to identify any potential overload scenarios at three critical areas of the Isle of Wight network, which are at the two BSPs and the interconnectors. At the moment, if a potential overload condition is detected then the ANM system will issue proportionate output reduction signals to the associated generation in accordance with the SSEN Last in First Out (LIFO) policy for generator output curtailment. A calculation is then done in the ANM algorithm set up to determine which generators should be constrained and the signals are sent directly to the generators. If the likelihood of an overload condition developing is reduced, then the level of curtailment is correspondingly reduced.

The System Operators in the control room can observe the full operation of the ANM system but can only interact with it if an error is reported.

Due to the existing firm connection agreement with Cowes Open Cycle Gas Turbine Power Plant, SSEN advised that potential overload conditions were calculated after subtracting the 140 MW firm connection from the available capacity. This leaves approximately 44.5 MW of available capacity to be utilised on the network through the ANM platform. SSEN mentioned that they do not guarantee a certain level of generation export through the ANM scheme and emphasised the point to future connections that the generator is accepting constraints, but crucially are avoiding excessive reinforcement costs. At the same time a larger ANM platform is being planned in the South Coast region, which is to be used to solve network constraints at transmission level. The South Coast transmission network will operate under N-3 security conditions and this may require the application of further constraints to generation on the Isle of Wight.

Due to confidentially obligations, SSEN were not prepared to share documentation on the key network assumptions that are embedded into the ANM platform. However, in summary, SSEN recognise that the costs to gain a connection to the ANM system has to be reviewed from their initial investment offer, which may explain why there has not been a big uptake since its deployment in 2017. For this reason, the ANM platform is continually evolving.

T: +44 (0) 1235 753000
E: enquiry@ricardo.com
W: ee.ricardo.com