A New Energy Centre for Sark

Les Laches

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RENEWABLES WIND TURBINES SOLAR PV ENERGY CENTRES BATTERY STORAGE GROUP

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1. Introduction

Scope of Report

1.1 Infinite Renewables Limited (IRL) has been appointed by Chief Pleas to prepare a detailed design for a New Energy Centre (NEC) on the Island of Sark. The role of the NEC is to provide all of the electricity generation needs for the Island in a new purpose built facility to be owned and operated by an Island owned not for profit energy company.

1.2 The NEC is designed to meet existing and future demand through the sizing of proposed generation and designing of space for future expansion.

1.3 Two options for the NEC are proposed. Option 1 is powered wholly by diesel generators with the ability to add renewable energy technology in the future. Option 2 is designed to be powered predominantly by renewable technology with back up diesel generation for resilience and times of low generation.

1.4 This report considers a range of factors that have influenced the design of the NEC under both options, prioritizing:

– resilience of supply
– value for money (both capital and operational expenditure)
– environmental and visual impact
– logistics of delivery and installation and on-going maintenance.

1.5 This report starts by reviewing the design considerations for introducing a renewables led system to the Island, given that this represents the biggest change from the status quo on the Island.

1.6 The design for each option is then presented and an indication of generation mix given.

1.7 The capital and operation costs of each option over a 25 year period are then presented.

1.8 The report concludes with details on timing and logistics.

2. Design Considerations

Design Standards

2.1 All of the proposed generation has been specified to meet the requirements of the NEC Design Scope and which can be installed to meet UK Electricity Safety, Quality and Continuity Regulations 2002 where appropriate and practical.

2.2 Electricity supply to the distribution network will be such that the supply to customers will be within the frequency range of 50hz ±1%, and maintained within the voltage range of 400/230 +10% to -6%.

Site Location

2.3 The NEC will be located at Les Laches on the eastern side of the Island. This location has the benefit of having Island owned land on which to locate much of the infrastructure, and also being accessible to bring the infrastructure to the site with minimal disruption to roads, trees and hedgerows.

Background Studies

2.4 Both options will require new infrastructure to be introduced to the Island at Les Laches. In addition, Option 2 will introduce wind turbines and a solar farm compared to Option 1

2.5 In order to assess the suitability and impact of these new elements, a number of background studies have been undertaken which have helped influence the final design and provide supporting information for a future planning application if pursued.

Ecology

2.6 BSG Ecology has undertaken a desk-based assessment on the potential impacts of the renewable technologies, drawing on the detailed records collected by Societe Serquaise and Guernsey Biological Records Centre.

2.7 The assessment focused on the flora and fauna that might be impacted by the wind turbines and solar farm in the Les Laches location and the findings have been reported back to Societe Serquaise in a presentation. The findings are summarised below, and habitat plans included in Appendix A.

2.8 The solar farm will cover an area of around 0.5 ha comprising tables of raised panels, interrow access and a small substation. Vegetation will continue to grow under the panels and the impact on the flora and fauna of the solar farm is considered minimal.

2.9 The wind turbines have a small footprint and the foundation of each turbine will remove around $64m^2$ of grassland. This is not considered to represent any significant impact on the flora or fauna of the fields. In order to bring the turbines to site, small sections of hedgerow will need to be removed, but the amount has been minimized in the layout design.

2.10 The main impact on wildlife from the wind turbines will be in the form of collision risk for bats and birds.

2.11 Having reviewed data and records, overall, there is nothing to suggest that the proposed location of the development is an exceptional bird or bat foraging resource.

2.12 There will be some migration of birds through the site however, birds will typically move low to the ground during high winds and are unlikely to fly at the height of the turbine blades.

2.13 If there are seasonal prey emergences and certain weather conditions, it is possible that the development location will have more bat use. However, the open and exposed nature of the site means activity is likely to be close to ground level when the turbines are turning. Prey is more likely to congregate around the coastal slope and woodland edges as these areas are better habitats for bat foraging.

2.14 A number of mitigation strategies have been put forward as options that could be implemented if desired. These include:

- feathering the blades at idle (pitching the blades out of the wind when wind speeds are too low to generate at 3 m/s or below)
- Enhancing the surrounding linear features (hedgerows) to create stronger bat foraging routes to discourage movement across the turbine fields (see Appendix A)
- Preparing a construction environmental management plan

2.15 The ecologists recommend that the Island utilises a mix of primary, secondary and tertiary strategies, to reduce and avoid potential ecological impacts to local species and habitats. However, it is important to note that there will be incidental bird and bat fatalities that cannot be avoided. These tend to be very low level and unpredictable.

Aviation

2.16 Civil Aviation Rules stipulate that because the wind turbines are within 30km of both Guernsey and Jersey airports, both must be consulted with regarding the potential impact on radar. Specialist consultants Cyrrus have been engaged to review the impacts. Impacts on Jersey airport have been considered first, and a Radar Line of Sight Assessment carried out to assess the impact on the Primary Surveillance Radar (PSR) at Jersey airfield (Appendix B). Detailed radar modelling shows that whilst Radar Line of Site does exist between the proposed turbine and the Jersey airfield PSR, the volume of shadowed regions beyond the proposed turbines are expected to be relatively small and considered operationally tolerable. The area immediately above and around the turbines is expected to only impact a single clutter cell of the Jersey Airfield PSR, and the turbines will not cause track drops for the PSR. No mitigation is therefore required for Jersey's airfield.

2.17 Guernsey have confirmed that the turbines would be in line-of-sight and expected to have an impact upon their S-band radar. As impact on these radar would be operationally unacceptable, mitigation measures may be required. The most likely mitigation is a combination of using Jersey radar and 'blanking' the turbines on their radar. This is an accepted mitigation for turbines, especially for low rise small clusters of turbines and this is therefore unlikely to cause a fundamental objection to turbines being included in the proposal. A more detailed study will be undertaken to confirm the necessary mitigation once the decision is made whether to proceed with the turbines or not in the interests of costs. There may be a financial cost associated with the mitigation measures, but these are not considered to be prohibitive and a realistic budget of £10,000 has been included in the capital budget estimate.

Microwave Links

2.18 Wind turbines have the potential to impact on fixed microwave communication links. We have consulted Sure Telecom who have confirmed that the turbines are positioned outside of the zone of potential interference.

Noise Assessment

2.19 Wind turbines create noise when the blades are turning (mechanical and aerodynamic noise) and when the turbine is turning into or out of the wind – yawing. A simple desk based noise assessment has been carried out to identify how noise from the turbine could impact on the nearest sensitive noise receptors.

2.20 The desk based assessment does not include an assessment of background noise, nor does is take into account topography, vegetation or climatic conditions such as wind direction. It therefore represents a worst case scenario.

2.21 The receptors are the nearest two properties (assuming residents have an open window or are just outside of the property). At the request of Société Serquaise, we have also extended the assessment to Les Autlets – to measure the impact on the Guillemot colonies.

2.22 The closest property to the turbines is Pres de Creux. The desk based assessment calculates that the maximum noise recorded at that property would be under 45 dB. This is equivalent to the noise level of light rain or the hum or a refrigerator. However, xsince the property is in a valley below the turbines the actual sound impact is likely to be less than 45dB.

2.23 The next nearest properties, those on Rue Des Laches closest to the turbines have also been assessed and the maximum noise level of the turbines at these properties is less than 42dB.

2.24 At Les Autlets the noise from the turbines would be no more than 35dB – equivalent of a whisper.

2.25 The results of the assessment are included in Appendix C.

Shadow Flicker

2.26 Under certain conditions, wind turbines have the potential to cause a phenomenon called 'Shadow Flicker'. This is the flickering effect caused when rotating wind turbine blades periodically cast shadows over neighbouring properties as they turn, through constrained openings such as windows.

2.27 A shadow flicker assessment has been carried out, which shows that there will be less than 1% of the year when shadow flicker could occur for short periods of time at the nearest properties, with the majority of the calculated impact landing on Pres de Creux. However, the software is not able to account for the fact that this property is located lower down in the Harbour Hill valley, and therefore the predicted potential for shadow flicker to occur is unlikely to happen. Shadow flicker mitigation is not deemed to be necessary.

2.28 A copy of the assessment is included at Appendix D.

Visual Impact

2.29 The NEC will require planning permission for its various elements. The Development Control (Sark) Law, 1991 identifies a number of considerations to be taken into account in the determination of such applications, including (5a) - the effect the development would have on the natural beauty of the area, and (5e) - the extent to which the development would detract from the character of the area.

2.30 The three main elements of the NEC will be the solar farm, Energy Centre Building and two wind turbines.

2.31 The solar farm will consist of 5 rows of panels on a ground mounted frames which will cover an area of approximately 0.5ha. The highest point of the panel will be approximately 2.5m from ground level and therefore, the visual impact will be minimal. The location of the development is far from the island's centre and away from famous landmarks such as Le Coupée.

2.32 The Energy Centre Building will be the same ridge height and style as the adjacent abattoir and therefore will not be a significantly noticeable feature in the landscape beyond what is already there.

2.33 As the most dominant feature of the proposal, a detailed visual impact of the proposed turbines has been undertaken and included at Appendix E

2.34 It would have been possible to generate the same amount of power from a single taller turbine, however, as well as providing greater resilience, two smaller turbines are considered to create less visual impact.

2.35 The visual impact has been assessed from a number of key vantage points on the Island, namely – La Collenette, The Hogsback, 'Sark Henge', La Plaisance, South side of La Coupee and Le Manoir/Stocks Meadow. Photomontages of these views are included in Appendix E.

2.36 When exploring the potential impacts of the proposed turbines on the landscape elements, the assessment shows that the proposal would not negatively harm the valued aspects of the island. The placement is on a simple landscape with little land cover which helps to decrease susceptibility.

2.37 Similarly, the viewpoints illustrate how the proposed turbines had a mainly minor or negligible impact on visual receptors and would not cause any irreversible harm.

2.38 The main impacts will be on recreational users of the East Island footpath that runs between Harbour Hill and Les Laches as they walk past the turbines, and recreational users of Creux Harbour from where both turbines will be visible.

2.39 The development is reversible and temporary meaning any harm on the landscape and visual receptors is not permanent and can be reversed through the decommissioning of the turbines in the future.

2.40 The overall impact of the development is likely to have on the landscape and visual receptors ranges from moderate to negligible at the various receptors and viewpoints assessed.

Ground Investigations

2.41 GeoMarine Guernsey has been commissioned to undertake an assessment of the ground conditions in the solar and wind turbine fields.

2.42 The ground investigation was undertaken by Geomarine - Guernsey, to provide an assessment of ground conditions underlying the proposed wind turbine, with respect to geotechnical properties to support engineering design

2.43 The intrusive ground investigation works were undertaken by Geomarine – Guernsey on Friday 17th May 2024.

2.44 The majority of the site comprises a relatively thin surface layer of cohesive periglacial head deposits (0.50 to 0.54m), of which the top 0.30m is likely to be re-worked due to the current and historical land use and has therefore been defined as topsoil. Beneath the cohesive head deposits is a variable thickness of granular head deposits (1.50m to 2.10m) atop weathered bedrock, although initially logged as "red igneous material" this has subsequently been redefined as gneiss rock type following further assessment.

2.45 A standard gravity foundation (8m x 8m) is proposed for each turbine as the bearing capacities at the proposed wind turbine locations allow for this type of design. The foundation design is included at Appendix F. The ground mounting system for the solar panels will consist of a number of metal piles screwed into the ground (up to 1.5m in depth) to support a framework for the panels.

2.46 The Ground Investigation is also included at Appendix F.

Wind Resource Assessment

2.47 A wind resource assessment has been produced by Digital Engineering – a UK company that specialises in site assessments for wind power schemes using a computational fluid dynamics model. . The report (Appendix G) confirms an average windspeed at turbine hub height of 7.0 m/s (90% confidence). This confirms that the Les Laches site has excellent wind resource.

2.48 The report also considers the impact of locating two turbines in close proximity to each other, known as wake effect. The report estimates wind turbulence at the site due to buildings/structures and landscape topography and considers 1 in 50 year extreme wind gusts. The findings of this report have been taken into account when selecting a suitable wind turbine model that can withstand the predicted wind conditions.

3. New Energy Centre Design Proposal

Existing and Future Demand

3.1 The starting point for the design of the distribution grid and NEC is the demand for electricity both currently and in the future.

3.2 Key inputs to an assessment of demand are maximum and minimum demands for power at any given time, and the total daily demands.

3.3 Future demand is very difficult to predict but will be driven primarily by customer numbers and the average property electricity usage. It is anticipated that future electrical demand will grow significantly as electrical appliances and electrical based heating systems are increasingly introduced into Sark homes.

3.4 Historic electricity load data for Sark has not been available whilst the existing grid is in private ownership, and this limits the accuracy of the modelling and estimates on renewable generation penetration.

3.5 There is also a high degree of uncertainty about the volume and pace of future growth and the Island will need to closely monitor demand once the new grid is operation.

3.6 The key design principle is to initially oversize the NEC generation capacity to allow for some growth and to ensure maximum efficiency in the logistical costs of bringing new equipment to the Island. If further generation is required in the future, allowance for growth has been made in the design and layout of the system to accommodate this.

3.7 Existing demand is estimated at an average low point (overnight) of 80kW and an average peak (daytime summer) of 300kW. Both NEC options have been designed to work within this range.

3.8 The total annual demand in Year 1 is assumed to be 1,400,000 kWh.

3.9 As future growth is likely to be driven by a switchover to electric cooking from gas/oil, the peak load is expected to grow and an average peak load of 400kW has been modelled. This represents a 25% increase in peak output, although it should be noted that this increase is concentrated around mealtimes and does not mean that uniform growth of 25% has been modelled. The overnight low of 80kW is assumed to remain in the future (as this represents a worst-case scenario) and the generation system is therefore designed to work within this range.

3.10 The generation assets can also handle additional growth in peak demand from day one (up to 700kW) and are therefore capable of handling unexpected surges in power demand.

3.11 Once the peak load approaches the initial design capacity, additional generation can be added to the system and connected to the distribution network as further described below.

3.12 The LV distribution board and HV system is capable of accommodating a maximum peak capacity of 2,500 kVA, meaning that additional generating assets and battery storage can be added in the future if there is a significant upturn in load.

Les Laches Hub

3.13 The NEC will be located at Les Laches where suitable land is available to accommodate the new infrastructure and future growth if needed. At the heart of the NEC will be a new steel portal building similar in style, and located next to, the abattoir. This building will house diesel generators, an LV electrical distribution panel, and a workshop for repairs and spares, in three separate rooms. The building will be the same design and layout for both generation options as the renewables led option will always be backed up by a diesel system that can fully meet the Island's demand in the event of no renewable generation.

3.14 The building will be 10 x 16m footprint and 4m to eaves, which will place it at a similar ridge height to the abattoir due to the difference in ground levels. Plan and elevation drawings of the building are included at Appendix H.

3.15 The building will be a steel portal framed building, with fire retardant composite roof and side panels. All steelwork will be hot dipped galvanized finish to help protect it from the coastal elements.

3.16 The section of the building that will be used for the diesel generators will feature louvered panels to allow for natural ventilation through the building.

3.17 Wide roller shutter openings will be included to allow for the installation and replacement of the diesel generators.

3.18 Space has been allowed for four generators and three bunded fuel tanks within the energy centre, although the initial design under Options 1 and 2 is for three generators. As demand grows and generators require replacement, larger capacity models can be switched in without requiring additional space. An area adjacent to the energy centre has also been kept vacant, which could accommodate an expansion of the building in the future if required.

3.19 The design scope requires sufficient storage tank capacity to allow the Island to be run entirely by diesel generators for 5 days without fuel deliveries to allow for a worst case scenario. The selected generators would require around 5,500 litres of fuel to run for 5 days. The Island already owns a 10,000 litre bunded fuel tank, and two additional 5,000 litre bunded fuel tanks have also been allowed for.

3.20 A new access track will be created through the field to the NEC building and turbine in the north east corner. This will allow for a suitable turning radius into the site and minimizes the amount of hedgerow that would need to be removed.

3.21 Access to the second turbine will be from the existing track to the Les Laches tip, with a small penetration through the hedgerow at the bottom of the track.

3.22 Data sheets and/or plans for all the main capital items are included in Appendix I and a site layout plan included at Appendix J.

LV Distribution Panel

3.23 The LV distribution board will be located within the NEC building. All the generating assets and BESS will be connected to the panel (incommers) and two feeds will exit the board (outgoers) to be connected to two step up transformers immediately adjacent to the building.

3.24 The panel will have a busbar rating of 4000Amps and up to 100kA 1s and comprise 2 busbar sections.

3.25 Spare capacity is included on the board to add additional generating assets in the future.

3.26 The LV distribution board provides the interface between the generating assets and the distribution system with the outgoing cable and step up transformers included in the distribution system scope.

Option 1 Diesel Run System

3.27 For a Diesel only run system, we have selected three new diesel gensets that use a Cummins 350KVa generator and Stamford alternator. This is the starting point for the diesel only generation system and closely mirrors the existing set up at the Island power station, but is a slightly more efficient mix of generator sizes.

3.28 Each engine can provide 256kWe of prime power, servicing a theoretical peak demand of around 750kWe. Allowing for one generator to be out of service at any given times would reduce the peak demand to 500kWe. The generators can handle a 60% loadstep with a voltage drop of around 10% (G2 rating), which is in keeping with the standard for grid power. This means they can respond to fairly significant surges in load demand (or drop) without causing issues for the grid. Since there are no single large loads on the Island which could cause significant loadsteps, these will be suitable for responding to the demands of the Island.

3.29 Running diesel generators at low load should be avoided both for longevity of the engine and overall efficiency. Therefore, until demand grows, we would not recommend the Island installs additional generators at this stage to cater for potential future growth but instead, responding to the increase in demand as it occurs. With three gensets, there is inbuilt resilience in the system to allow for engine downtime, but it will be important that their usage is rotated to keep the generators in optimal condition. A microgrid control system would therefore be installed to ensure efficient operation of the generators.

3.30 The generators would be capable of 'black start' i.e not requiring on electrical connection to start. This is important to allow the island grid to restart in the case of a loss of power.

3.31 The selected generators have been designed to run on diesel as opposed to biofuel because of their better fuel efficiency, cost and ability to perform in cold temperatures. The use of biodiesel is not appropriate within the generators and would invalidate the warranty.

3.32 The selected generators are containerised, which will assist in reducing noise impacts for those working at the NEC.

3.33 The generators would be located at the Les Laches hub and a new cable connection to the electrical distribution network would be required. This new connection has not been included within the design and costings for Option 1.

3.34 In common with Option 2, a new low voltage electrical distribution panel would be required at the Les Laches Hub. This has been allowed for in the design and costing of the system.

3.35 Whilst the LV panel could be designed to only accommodate the diesel generators, we recommend allowing sufficient space for renewable generation to be connected if desired in the future.

Option 2 Renewables-led System

3.36 The demand profile of the Island and natural resources available make it highly suitable for a mix of both wind and solar power. To optimize the generation, BESS is proposed that will allow generation to be stored at times of excess generation and released during periods of low generation.

3.37 Our proposal places all the renewable sources, battery storage and diesel generators on a common busbar, meaning that they are all capable of responding to load demand. The priority and control strategy for managing the generation is set out below, and central to its functioning will be a storage system.

3.38 The renewable generation has the ability to meet 100% of current Island demand when generating at peak output, although we estimate that the penetration rate of renewables over the course of a year will be around 80%, meaning that 20% of the power will be supplied by diesel generators.

Battery Energy Storage System (BESS)

3.39 BESS allows for excess renewable generated power to be stored and then released back into the grid at times of low or no generation on the Island. It also helps stabilise the grid as it manages the varying levels of load and generation. We have proposed lithium-ion battery cells as they have excellent charge/discharge response times, and grid forming inverters that will provide the desired grid voltage and frequency to allow synchronization of the various renewable generators.

3.40 The BESS can operate in 'island' mode, i.e it does not require a diesel generator to also operate in parallel.

3.41 The total power capacity of the BESS we propose is 700kW with 750kWh of storage capacity. The BESS can operate at 100% depth of meaning its useable capacity is 750kWh of useable storage. This will meet around 8 hours of average night loads (90kW) when the solar panels will not be generating and will help keep the use of the diesel generators as low as possible, even when the wind turbines are not generating.

3.42 The BESS is modular and can be increased in size in both output and storage capacity in the future.

3.43 The BESS is capable of being housed within the energy centre building, however, to reduce fire risk, we recommend that containerized systems are used that include in-built fire suppression and air conditioning systems. In our design, 10ft containers are specified in order to allow for ease of deployment on the Island. The inverters are located on the outside of the containers to assist with cooling and are outdoor rated.

Wind Turbines

3.44 We have proposed two turbines for the NEC to maximise resilience and minimise the size of the turbine required and therefore visual impact.

3.45 We have proposed 2 x Vestas V29 turbines, which have a maximum rated power of 225kW. Each turbine would have a hub height of 30.5m and a rotor diameter of 29m, giving a total tip height of 44.5m. These turbines, along with others from established manufacturers in this output range, are only available on the second-hand market. The turbines will be sourced, refurbished and installed by Business in Wind – specialists in the decommissioning and refurbishment of wind turbines with extensive experience in delivery and installing wind turbines in challenging locations.

3.46 The turbines will typically have first been installed in Europe around 10 years ago, and whilst still viable, will have been taken down so that they can be replaced by larger more powerful turbines as technology has developed. Business in Wind will undertake a full refurbishment or any components that are showing signs of degradation or will adversely affect performance, such as blade repairs and replacement of bearings, such that it is in a state where it can operate with reliability over a 25 year life-span and be covered by a 25 year warranty by an Operations and Maintenance provider if required.

3.47 The estimated windspeed at 30m hub height is estimated at 7.0 m/s. The cut in wind speed – the minimum wind speed at required to generate power is 3.5 m/s. The cut-out wind speed is 25 m/s – this is the speed at which the turbine shuts down for safety reasons.

3.48 The turbines are Class II machines, meaning they are suitable for the maximum wind speeds expected on the Island and have a rated survivable wind speed of 55 m/s (123 mph).

3.49 At this average wind speed each turbine is estimated to be capable of generating 741,500 kWh per annum resulting in a total wind output of 1,483,000 kWh per annum gross. It would be normal to assume some reduction in this output estimate to account for periods of downtime for maintenance and losses. Taking availability and losses into account, Digital Engineering estimates that the net output could be 1,155,000 kWh (90% confidence level) or 1,323,000 kWh (50% confidence level). These estimates are based on 20 year average wind speeds and there will always be some degree of variance in output year on year.

3.50 The turbines have been positioned so as to minimise their interference with each other in the prevailing winds – known as wake turbulence. One turbine will be located in the northeast corner of the field in which the new hub will be located, adjacent to the NEC building. The other turbines will be in the southwest corner, 90m apart, which is over three rotor diameter apart – the minimum required separation.

3.51 Whilst the background studies have not identified a need for specific programming, the wind turbines can be programmed to implement noise and shadow flicker mitigation if needed.

Solar Farm

3.52 Solar has a key role to play in energy generation on the Island, given that historic data suggests peak energy usage in the summer daytime (around midday). This is reflective of the impact of tourism on energy usage on the Island and is counter to UK mainland energy demand, which peaks in the winter.

3.53 To account for the demand usage profile and to take advantage of the ability to time shift to battery storage, we have proposed an east/west oriented solar system.

3.54 Solar generation from solar farms will be influenced by the solar irradiance level received. Solar irradiance is the power of solar radiation measured in W/m2 and depends on the elevation above sea level, the angle of the sun (due to latitude, season and time of day) and scattering elements such as clouds.

3.55 The solar irradiance level on Sark, orientation an angle of the panels proposed, is such that the specific yield from the solar farm is estimated at 1,067 kWh/kWp. That means that for every 100kW of installed capacity, the solar farm can expect to generate a maximum of 107kWh of energy.

3.56 Advances in technology mean that panel capacity is ever increasing. We have designed for 550W size panels, but the precise output will depend on what is available at the time of order. The panels will be Tier 1 – the highest rated by independent PV industry analysts.

3.57 We have designed a system with a peak generating capacity of 510kWp from 920 panels. This will be constructed on 5 sets of east/west tables, extending to approximately 50m in length each (23 panels in landscape orientation). Each table will have four panels per row orientated east, and four panels orientated west. The tables will be approximately 2.5m maximum height and raised approximately 0.75m off the ground which will allow for ground maintenance and grazing by sheep if desired.

3.58 At the end of each table will be an 80-100kW inverter to convert the power from dc to ac current ready to be used in the grid.

3.59 The tables upon which the panels will be mounted have been specifically designed to take account of the wind speed, ground conditions and coastal sea air.

3.60 A ground anchor system has been selected to secure the mounting frame to the ground, and the anchors are coated with a minimum galvanized coating of 85microns. High Grade 6061 aluminium alloys will be used for the rails and fasteners will be Grade A2 304 stainless steel. Bolts and washers will also be appropriate for the coastal location.

3.61 There is further space within the field that could accommodate an expansion of solar generation in the future if required. Because LV cables are being used to connect to the main substation, there will be insufficient carrying capacity in the LV cable to connect a material increase in output to the system. Therefore, new cable would need to be laid to connect an expansion of the solar farm to the substation.

Diesel Generators

3.62 Whilst it would be possible for Option 2 to be 100% renewables led, it would require very large amounts of battery storage and an oversupply of generation to provide sufficient security of energy supply for the Island. Diesel generators are therefore included within the design for Option 2 and at the same specification as per Option 1. This is so that the system has resilience in the event of long periods of low or no renewable generation. They will be specified to run as Prime power rather than standby power.

3.63 The total amount of diesel that will be required under Option 2 compared to Option 1 (100% diesel) will depend on how much electricity is generated by the renewables (which will vary from year to year) and the actual demand profile over the year. The generators will also need to be run periodically to keep them in a good state of repair and this will be included in the philosophy of the control architecture as described below.

3.64 We estimate that around 20% of the Island's power will be generated via diesel generators. Since the generators require a degree of cycling, to maintain them in optimal condition, this is considered a suitable level of usage.

Power Management Control and Strategy

3.65 All of the generating assets and the BESS will sit on a common busbar meaning that any combination of simply can meet demand. The system will be voltage regulated, allowing it to instantaneously respond to fluctuations in demand. This is how the existing grid functions, with the diesel generators fitted with in-built voltage regulation.

3.66 As choice of generation type is introduced into the NEC an automatic control system will be central to the functioning of the NEC – balancing load and demand and prioritizing the use of renewable energy. The controller(s) monitor demand and generation at each asset and react accordingly to constrain or release generation at each asset as required by way of MODBUS signals.

3.67 We have provisionally selected a DEIF power control system, that has proven experience of working with renewables in off-grid island applications. The DEIF control system is compatible with all the types of generation that are proposed in the NEC.

3.68 Each generating asset will be connected to an individual controller ensuring resilience in the event of a failure of one controller or asset. The central controller will dispatch the generation system based on site loads and available generation, prioritising renewable assets over diesel generators.

3.69 The control strategy can be written to implement any desired sequence. Whilst some iterations and adjustments might be made once the NEC is commissioned, the initial proposed strategy will be as follows:

- If demand > renewables supply, discharge battery up to 10% State of Charge (SOC)
- If renewables supply > demand, charge battery up to 95% SOC
- If battery SOC > 95%, constrain solar or switch on heat system
- If battery SOC > 95% and solar fully constrained, constrain turbines
- If battery SOC<10%, turn on diesel generator 1 until SOC reaches 50%. Diesel generators to be cycled 1-3
- Diesel generators to be cycled to allow for minimum run time to maintain them in a serviceable condition.

3.70 The control system is modular, and new controllers can be added as new assets are added in the future, with up to 16 controllers being able to work as a single microgrid system. It is designed with user friendly functionality and Island engineers will be provided training on the use and set up of the system.

Heat Control System

3.71 Due to a combination of oversizing renewable energy assets and the daily fluctuations in energy demand across the Island, there will be times when the energy assets produce more electricity than is being consumed. The first step when this occurs is to charge the BESS for use at a later time. However, once the BESS is full, the generating assets either have to be constrained or an alternative use found for the power.

3.72 Constraining the solar and wind is possible via the micro grid power control system and does not compromise performance or result in additional costs for the operating system.

3.73 In terms of an alternative use for any excess power, this could be sent to immersion heaters in Islanders' homes at a reduced tariff to provide domestic hot water. Households that opt to take part in the scheme would have a remote relay switch added to their existing immersion heater that would be sent a signal to switch on/off via an RF signal when there is excess capacity. This would be controlled using a suitable interface with the main micro grid controller which would look to switch on banks of immersion heaters in rotation. The power sent to the immersion heater would need to be separately metered if a reduced tariff was offered.

3.74 Data from the first 12 months of operation of the NEC would need to be analysed in detail to evaluate the business case for using any excess power in the form of heat.

4. Capital Expenditure and Operating Costs

New Energy Centre – Option 1 Capital Costs

4.1 To allow for existing and future growth in demand, the same size building is proposed at the energy centre. Three generators would be required from Year 1, but additional generators would be required to meet the potential increase in demand. As demand grows, additional generators could either be added to the Energy Centre or larger capacity models swapped in.

4.2 The gensets have a run life of 20,000 – 30,000 hours, so we have assumed the replacement of the gensets every 4 years. For comparison with Option 2, we have assumed an operational life of 25 years and have identified the capital expenditure in Year 1 and the replacement infrastructure costs over the 25 years.

4.3 An LV distribution board would also be required, and the same specification is used as per Option 2 in order to allow for renewables to be added in the future.

4.4 The Initial Year 1 capital costs for Option 1 are estimated at £602,184. The inclusion of replacement generators every 4 years is estimated to increase the total 25 year cap ex to £1,105,309.

Energy Centre and Board	£	355,000
Diesel Generators	£	100,625
Control System	£	6,000
Design Studies	£	30,000
Travel and Subsistence	£	4,000
Contingency	£	39,650
Project Management	£	66,909
Year 1 Sub-Total	£	602,184
Replacement Generators	£	503,125
25 Year Total	£	1,105,309

Option 1 Operational Costs

4.5 We would anticipate that the same number of Island Engineers would be employed whichever Option is installed. The main operational costs for Option 1 will be the diesel – the cost of which can be highly volatile. For the purposes of this report, we have assumed an annual diesel cost of £0.25 per kWh, in line with the current rates. We have assumed a 2% p.a increase in the total cost to reflect increase in usage and/or increase in the cost of diesel. Over a 25 year period, the total cost of diesel under this scenario would be £11.7m.

Option 2 Capital Costs

4.6 The estimated capital spend for Option 2 is £3.2 million. This is based on prices and exchange rate assumptions at the time of this report. An 8% contingency has been included which would help with any significant variations in prices and exchange rates when the orders are placed.

4.7 The capital budget also includes for a number of spare components to be bought and stored on the Island, to ensure that repairs and replacements can be quickly attended to if required.

4.8 Detailed costings for Option 2 are included in Appendix K, and a summary set out below.

Energy Centre and Board	£	355,000
Turbines	£	1,020,770
Solar Farm	£	320,730
Diesel Generators	£	110,625
BESS	£	647,855
Control System	£	73,000
Design Studies	£	55,000
Travel and Subsistence	£	42,000
Contingency	£	209,998
Project Management	£	364,372
Total	£	3,199,350

Option 2 Operational Costs

4.9 In common with Option 1, Option 2 includes diesel generators which will have an op ex cost associated with diesel consumption. Our model assumes that diesel will contribute around 20% of the total electricity supply to the Island under Option 2. Assuming the same growth model of 2% p.a, the cost of supplied diesel under Option 2 would be £2.16m over 25 years.

4.10 The other differential operation cost between Option 1 and 2 is the requirement for Operation and Maintenance (O&M) contracts for the wind turbines and solar farm and insurance for all the additional assets. An operational budget increase of £60,000 p.a compared to Option 1 should be allowed for. With 2% p.a increase in costs assumed, that would represent £1.92m of additional non fuel operational costs over 25 years compared to Option 1.

4.11 Therefore, the net difference between the operating costs is such that the diesel only Option 1 would attract £7.62m of additional operating costs compared to Option 2 over 25 years.

4.12 The additional operating costs of Option 1 more than offset the additional capital costs of installing Option 2 (c.£2.1million), even allowing for finance costs.

4.13 Option 2 also has the benefit of being able to reduce the unit price as demand increases, whereas the unit price of electricity under Option 1 will always be linked to the unpredictable cost of diesel, regardless of how much demand increases.

5. Logistics and Delivery of NEC

Programme Timetable

5.1 The installation timetable of the NEC will be influenced by the progress of the new distribution system, and when the Island are ready to proceed.

5.2 The preferred installation time for the wind turbines will be late spring/early summer or late summer/early Autumn. Installation outside of these times is possible but there is a greater risk of delays due to the weather, which in turn could impact on the cost of installation.

5.3 The first element of the NEC to install will be the energy centre building. This is delivered 'flat packed' and will be erected by Island builders. No specialist equipment will be required to be brought to the Island for this installation.

5.4 A new access track will also be created to the building.

5.5 The build phase for the NEC building is expected to be 4 weeks.

5.6 Once erected, the building can be used as dry storage for other materials brought to the Island.

5.7 Installation of the solar farm will take approximately 8 weeks.

5.8 The wind turbine works will take approximately 3 months, followed by a 1 month period of testing. This can be undertaken concurrently with the installation of the solar farm.

5.9 The BESS is delivered containerized and only requires a short period of installation and commissioning once it's ready to be used.

5.10 The diesel generators come containerized and ready to 'plug and play'.

Delivery of Goods to Site

5.11 All components of the NEC will be brought to the Island by boat – either the Sark Shipping cargo boat or the Normandy Trader landing craft, which has previously been used to bring the Island Crane ashore.

5.12 Assets have been specifically selected with the constraints of the Island crane (for unloading), Maseline harbour tunnel dimensions and capacity of the cargo boat in mind.

5.13 The BESS is transported in 10ft containers, which can be offloaded and maneuvered to site with the island crane, tractor and trailer.

5.14 Solar panels are delivered on pallets and can also be taken to site from the cargo boat via tractor and trailer.

5.15 Local quarried stone will be used for the access track and crane pad.

5.16 The greatest logistical challenge is delivery and installation of the wind turbines, which is set out below.

Wind Turbine Installation

5.17 The turbines are delivered in sections, namely three tower sections, three blades, a nacelle (which houses the generator and gearbox) and a foundation can. The foundation can is delivered in advance and set into the concrete foundation. The foundation is left for around

4 weeks to cure before the turbine is installed. The can is capable of being offloaded and transported to site using island resources.

5.18 The turbines will be refurbished in the Netherlands and from there will be transported overland to Granville. They will be loaded onto the Normandy Trader landing craft. The craft will stop en-route at Jersey and a large mobile crane and excavator added to the shipment. The craft will sail to Creux Harbour and land on the beach. The turbine components will be taken by trailer through Creux Harbour tunnel and up Harbour Hill. The dimensions of the crane compared to the tunnel have been checked and established. From there they will be taken to the site along the established lanes.

5.19 At the tight bends, telehandlers can be utilized to rotate the components around the corners.

5.20 Adaptations will be made to the standard installation method to take account of the maximum carrying capacity of the crane, such as installing the nacelle and generator separately.