Sark Electricity Review – New HV & LV infrastructure

Office of the Sark Electricity Price Control Commissioner

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Process

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1 Introduction

The Electricity Commissioner for Sark is currently undertaking a consultation into the price of Electricity. Currently this is charged at £0.66/kWh, which is a significant cost compared with other locations

Narec Distributed Energy (NDE) is an independent commercial consultancy, who specialise in renewable energy technologies, energy storage and electricity grid connections. We have been commissioned to undertake a number of analysis on behalf of the Electricity Commissioner.

This particular piece of work is to answer the following enquiry;

What would be the estimated cost of a new HV & LV network ?

We have based the cost of an all new network using common generic prices from the UK mainland. All equipment proposed is available 'off the shelf' to ensure that there are several options for suppliers. The renewable generation, battery storage are all shown as an indication only.

2 System

For this scheme we have assumed that a central high voltage 'ring' will have several 'tees' or 'spurs' to remote transformers. The proposed system could easily be coupled on to the existing diesel generation that already exists on site.

The voltage chosen to operate the HV network is 11kV. This voltage was chosen due to the readily available amount of cable, equipment and plant. This voltage was also chosen due to the vast number of companies trained and authorised to both install and operate at this voltage. The option to operate a 6.6kV system was rejected due to system losses, cost of plant & equipment and future proofing the island (6.6kV systems are being removed daily by Distribution Network Operators across the UK for superior 11kV systems).

As with all things in life cost is an issue, in this respect 'tees' or 'spurs' have been selected to reduce costs. These could be easily incorporated into the main ring by doubling up with the HV cable which would improve network resilience & flexibility at additional cost. As an exercise to produce an indicative cost for a new network these have been costed as 'tees'.

Transformer locations are shown with a blue circle on the following map. At no point is any property more than 500m away from a substation which is the realistic working limit of a 300 WNE mains LV cable (beyond this length you can encounter fusing, volts drop, impedance & flicker issues).

The main HV ring feeder is shown in red with the various tees marked in other colours. These could be combined into the main ring if required at additional costs.

There are a total of 10 wind turbines shown at various indicative locations, marked a red circle. These are only to give an idea of where these could be placed. There are also some PV arrays marked in yellow, again purely for indicative purposes. The main point of this part of the exercise was to provide an indicative route & cost for a new HV & LV network.

See below -

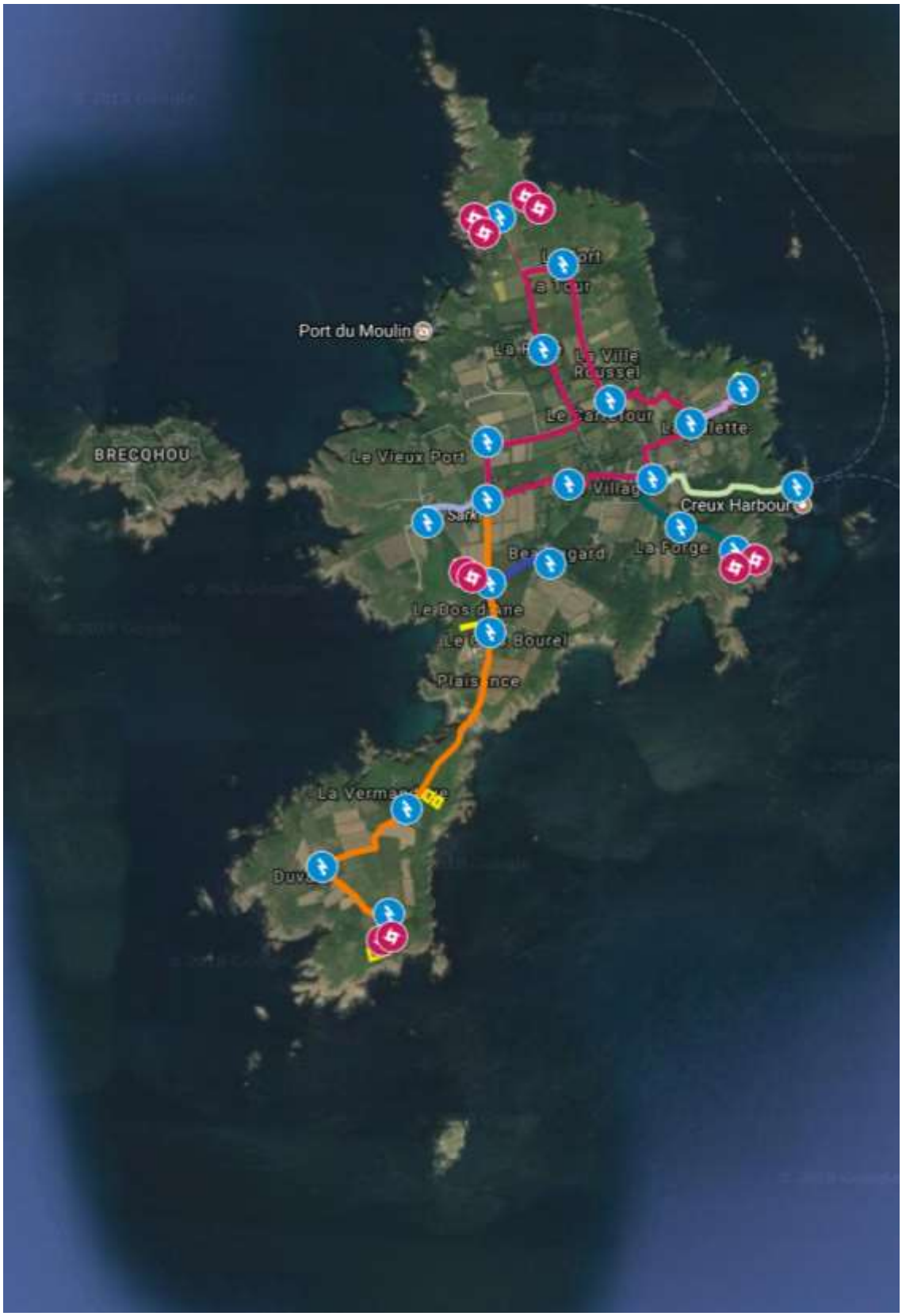

Figure 1: indicative HV layout

3 Assumptions

To produce an indicative price as accurately as possible generic UK prices have been used. The costs are based around one company carrying out the works in their entirety as one, cohesive scheme. This gives an economy of scale which is included in the pricing. The system is based on 250 individual connections with an average connection length of 30M. Obviously, some properties will be closer and some further away. A total of 25M of mains cable per property has been allowed to produce an average cost (you would generally use 10M per property for a typical UK housing estate).

The HV network is based on Google maps and not the exact load centres, but it does give a fairly accurate, indicative price of a new HV network. Again, generic UK prices have been used for cable, switchgear & transformers.

Additional costs for shipping will be incurred and these have not been included in this report due to timescale & financial restrictions.

Figure 2: indicative LV network with renewable energy

4 Equipment

All the equipment selected is commonly available from several wholesalers & manufacturers in the UK. Nothing has been selected which is bespoke or 'special order'.

HV cable – 185mm Triplex has been selected due to it's ready availability, ease of jointing and general all-round performance. This type of cable is in service with all the UK's DNOs & IDNOs and has a good record for reliability using polymeric (XLPE) insulation. Larger 300mm Triplex was considered but rejected due to the additional costs and relatively low fault level on the island. The benefits of reduced losses were considered but the additional costs make this very borderline. The total length is calculated as 10,543M which would require 11,000M to allow for jointing & termination losses. See below a typical example of this type of cable (shown in a clamp for mounting to cable tray as an example).

Figure 3: indicative cross section of Triplex cable

LV cable – a combination of 300 WNE cable and 95 WNE cables were chosen due to their ready availability, ease of jointing, ease of installation and general all-round performance. This type of cable is in service with all the UK's DNOs & IDNOs and has a good record for resilience & reliability using polymeric (XLPE) insulation. Other cable sizes & types are available but WNE (Waveform Neutral Earth) is basically an industry standard in the UK. The total length has been estimated at 10,000M of which 6,000M would be 300WNE and 4,000M would be 95WNE. See below for a typical example of this type of cable –

1. Segmental aluminium conductor
2. XLPE insulation (cross-linked polyethylene) colour marked for phasing
3. Mastic serving
4. Copper neutral earth conductor
5. Outer PVC serving

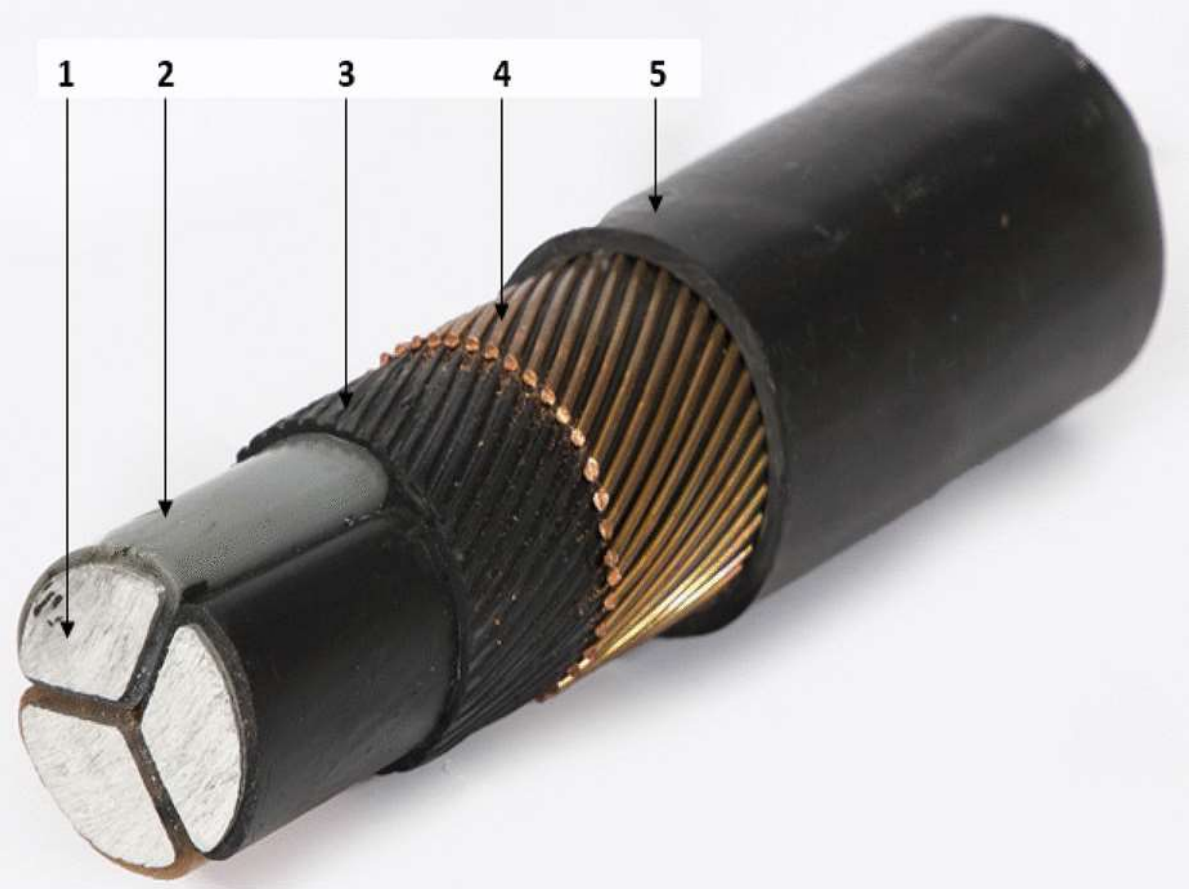

Figure 4: typical example of WNE cable

Service cable – service cables will be either 35mm aluminium hybrid cable or 35mm 3c hybrid cable. These cables were chosen due to their ready availability, ease of jointing, ease of installation and general all-round performance. This type of cable is in service with all the UK's DNOs & IDNOs and has a good record for resilience & reliability using polymeric (XLPE) insulation.

As the exact earthing arrangements of Sark are unknown all the cables can be sourced as either PME (Protective Multiple Earth) or SNE (Separate Neutral & Earth). PME cables can also be used for TT systems (No earth provided). If a complete new system was to be installed then PME earthing would be recommended, with the exception of farms & caravan parks which would require either SNE earthing (TN-S) or no earth (TT) respectively to comply with the current IEE wiring regulations (BS7671).

LV service cut out – a standard 100A maximum rating service cut out is proposed either single phase or three phase as required. These are commonly available and used by all the UK's DNO & IDNO's. A maximum of an 80A fuse would be installed. No costs have been included for any metering as these are generally provided by the meter operator.

See below, Lucy 100A service cut out -

Figure 5: indicative single phase service cut out

Transformers – some sites could be served by what is known as a Padmounted type transformer. These are very compact and take up very little space and are generally controlled by a transformer circuit breaker which is usually remote to the site. They generally contain their own HV fuses for additional resilience, safety & reliability. They come in sizes from 25kVA to 1000kVA and have a number of LV ways in which the appropriate size fuses could be installed. The number of LV ways is dependent on the size of the transformer. These are very cost effective but are really only suitable for Tees only. These are cost effective, low maintenance and have a very low visual impact on the surrounding area. The HV & LV area's can also be locked independently to allow access only to the appropriate key holders (Authorised Person or Senior Authorised Person).

See below for a typical example –

Figure 6: Typical Padmount 11kV substation

UDE – A UDE (Unit Distribution Equipment) is a fully contained 11kV substation comprising HV switchgear, transformer circuit breaker, transformer & LV cabinet. These simply bolt into position on a pre-cast concrete plinth and provide a quick, simply and easy solution to establishing a new substation. They are available in a number of sizes from 315kVA to 1,000kVA and have a number of options available for the LV cabinet.

Depending on the size of the UDE this could include an 8 way LV board or an ACB (Air Circuit Breaker) with 2

ways, ideal if there is a requirement for a single, large supply.

These can be specified for outdoor use which negates the need for a substation building or alternatively they can be housed inside a typical brick built substation or a GRP enclosure. All connections points are compatible with all currently available cable types in the UK.

See indicative picture below –

Figure 7: Indicative example of an 11kV UDE

Extensible Switchgear – This type of switchgear could be used where Tees are connected to the Island's main ring feeder. 11kV extensible switchgear has a central 'bus bar' which can be extended to allow for the connection of as many switches or circuit breakers as required. A typical tee off arrangement would have an incoming 11kV switch and an outgoing 11kV switch, a transformer breaker (for a local transformer) and an additional transformer breaker to control, operate & protect a remote padmout transformer or transformers.

This type of switchgear would be required at the main connection point of the largest generator, indicated as in the North as an example only. This would allow for the two 11kV ring feeders to be connected, the photovoltaic generation, the wind turbine generation and the battery storage. Frequency control, monitoring, voltage regulation etc would all take place at this location. By installing tele control all items of plant could be operated remotely if required.

See indicative picture below –

Figure 8: Extensible switchgear

5 Renewable Generation

As part of a new grid system renewable energy generation should be considered to significantly reduce the Island's carbon footprint, improve air quality and reduce the reliance on fossil fuel. This has been covered in another section of work and is only mentioned here as the possibilities are staggering. Renewable generation in the form of wind turbines & solar arrays could be gradually integrated into a diesel powered system, allowing the progressive reduction in fossil fuel usage. Correctly applied renewable generation coupled with large scale battery storage could soon replace diesel. In general renewable energy is low maintenance, simple

Indications of possible sites are shown on Figure 1 (page 4) but are purely for information purposes only.

6 Equipment costs

As has been explained earlier in this report the prices shown are indicative and based on an average of DNO prices in the UK. A service is a length of service cable, breeched jointed to a main cable and terminated in a 100A service cut out. HV cable is the cost of the length of the HV cable excavated, jointed & reinstated. All substations include HV & LV jointing work as required. The costs provided are fully inclusive of all works required. All prices are shown do not included VAT as this may not be applicable on Sark.

Low Voltage

LV service - £1,750.00 per property, total for 250 properties = £437,500.00

LV cable - £850,000.00

High Voltage

HV cable - £2,100,000.00

HV *substations* -

Padmount x 11 = £70,000.00

UDE x 4 = £160,000.00

Extensible x 4 =£210,000.00

Multi-panel (control) = £220,000.00

GRP enclosures x 5 = £105,000.00

Conctrete plinths x 20 = £180,000.00

Fencing x 4 = £12,000.00

Based on the information provided and by the use of Google Maps the total cost of a new HV & LV network on Sark to 250 properties is likely to be in the region of £4,344,500.00. This may be reduced with a full on-site assessment of the likely excavation requirements and ground type. A full detailed study may be able to remove one or two substations or even reduce cable sizes slightly.

There are several ICPs based in the UK who would be willing to quote for this work. A tender arrangement would give a clear view of what the exact costs would be.

7 Conclusion

Despite it's relatively small size the cost of a new electricity system on Sark is considerable. Costs savings could be made at the expense of reliability & resilience by using more HV tee's or by installing some sections of overhead network at either HV or LV. The benefits of this (cost) do not outweigh the advantages (reliability, resilience, aesthetics & safety) in our opinion.

8 Further steps

As the existing HV network on Sark is currently split between 6.6kV and 11kV a serious consideration should be given to standardising the HV voltage. Only one voltage is practical on such a small island and 11kV would be preferable due to the prevalence of this voltage throughout the UK and Europe, however if the installed cables are only 6.6kV rated then a 6.6kV system covering the whole island could be considered to give the

benefits of interconnection and the additional reliability & resilience this brings.

Alternatively, approaches could be made to look into establishing a sub-sea cable link with Guernsey. While this is a very expensive option is does allow for a very long term approach to electricity supply on the island and would allow for the export of renewable energy from the island as a possible long term revenue stream. This would all but negate this use of fossil fuel on the island to produce electricity and would bring the price per kW tumbling down.

Another option to reduce costs on Sark is to introduce renewable energy into the current generation stream. A full report based on this is to follow but a combination of even a few wind turbines & solar panels will significantly reduce the amount of diesel generation required on Sark. If individual homeowners were encouraged to install even a modest amount of PV and a small battery it would also significantly reduce the amount of diesel generation required on the island. As the island has it's peak demand in summer then additional photovoltaic generation is a very sensible & reliable way forward for the island of Sark.

Advancing Renewable Energy

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