GLENACHULISH HYDRO FEASIBILITY

Lochaber Environmental Group

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WIND | HYDRO | GEOTECHNICAL | SOLAR | HYBRID | STORAGE

Report Prepared for:
Lochaber Environmental Group

Glenachulish Hydro Scheme
Feasibility Study

Prepared by:
Green Cat Renewables Ltd

Disclaimer:
This Study has been prepared in accordance with the methodology set out herein and is subject to the qualifications, assumptions and restrictions as noted throughout the document. All computations and conclusions are believed to be accurate to the best of our knowledge, however, Green Cat Renewables Limited assumes no responsibility for the accuracy of data or other information supplied to us by other parties, the terms of which have been incorporated into this Study.

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EXECUTIVE SUMMARY

Green Cat Renewables has assessed the feasibility of a 544kW hydro scheme on the Abhainn Greadhain Burn in Glenachulish.

Scheme Design

It is proposed that a single intake situated on the Abhainn Greadhain Burn to abstract water, which is then piped via 1,335m of buried pipeline to a powerhouse. A hydropower turbine/generator converts the pressurised water to electricity before being returned to the burn via a tailrace.

Due to the forestry on the site a GPS topographical survey (topo) has not been undertaken so head and pipeline lengths have been deduced from map data. Therefore the figures used are not as accurate as onsite measurements.

Hydrology

The required CAR Licence (CAR/L/ 1138676) for impoundment and abstraction was approved on the 3rd of February 2016 granting a total allowed abstraction of 610l/s. The following conditions are also defined in the CAR licence (Note: the Q(X) is the flow rate that is exceeded during X% of the year):

- Abstraction can only start when the flow upstream of the intake is equal or greater than 54l/s but only when the flow immediately downstream of the intake is greater than or equal to 54l/s).
- The flow that must be delivered downstream of the intake when the flow upstream of the intake is greater or equal to 477l/s (Q(30)) is 82l/s).

Planning

Planning permission for the scheme was issued on 23rd November 2016. There are 12 conditions attached to this consent. All of the conditions are expected and standard for a development of this nature in this location in woodland and also close to dwellings where trees, noise, core paths and ecology are key issues to be considered.

The main issue with the current planning consent is the time limits to starting the consented development. Section 58 of the Town and Country Planning (Scotland) Act 1997 states that planning permission must commence within 3 years of the date of the decision notice or the planning permission shall lapse. LEG and GCR have met with the planner from the council who has confirmed no extension is available to the project but they would allow a phasing of the pre-construction surveys so a small section of works could start, enabling the planning permission to be initiated before it expires without commencing full works.

Grid Connection and Onsite Demand

An Offer Letter for a Distributed generation for the Greadhain (Glenachulish) Hydro project was provided by SHEPD, to Green Highland Renewables for a 700kW connection on March 2019 and subsequently accepted on the 26th of March 2019. Upon accepting the offer, Green Highland Renewables has paid the first payment of £12,302.40 (Incl. VAT at 20%) to SHEPD. The Second payment of £70,251.60 (Incl. VAT at 20%) is not due until 31st October 2019.

Revenue

The main sources of income that this scheme will benefit from are the selling price of electricity (assumed as an average of £55/MWh) and the FiT secured through pre-accreditation (£62.1/MWh). Due to the limited topo survey three heads levels have been provided. The following table provides a summary of the gross average annual revenue for the three cases:

Table 9.1 - Summary of annual revenues

Case	P50	1 year P90	10 year P90
111m head	£222,177	£183,453	£207,012
116m head	£232,854	£192,233	£216,951
106m head	£211,499	£174,672	£197,072

Operation Cost

The total operational cost based on an annual average generation (P50) is:

- 111m: £66,385
- 116m: £68,521
- 106m: £64,250

Capital Cost

The total estimated capital cost is £1,728,482.

Economics

The 20 year IRR at 10 year P90 Revenue range between 7.89-9.26% which is considered excitable for a hydro project. The next stage is to discuss potential routes to funding for the project.

Findings and Recommendations

The results of this assessment indicate that the Glenachulish hydro scheme is a viable scheme and the risks of the annual generation being lower are low.

The hydrology is solid and the long term predictions are based on historical data that goes back up to 35years. The gross head is uncertain but three cases have been studied and all of them showed good results. The main items in the CAPEX and OPEX have low uncertainty however there are risks associated to tree felling, stone availability and agreements with the forestry commission. The results of this assessment show that the scheme could be able to support a certain level of additional unforeseen costs and still be viable. However, the mitigation and recommendations explained in this report should be followed to avoid high unforeseen costs that could potentially risk viability.

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1 INTRODUCTION

This feasibility study assesses the viability of a hydro scheme situated on the Abhainn Greadhain Burn in Glenachulish. Green Highland Renewables have developed the project to its current stage and have decided not to progress the scheme. The project has planning permission, abstraction licence and grid connection. The Lochaber Environmental Group (LEG) have an opportunity to take the project forward. This report will assess all documents and permission that relate to the project. An independent energy yield assessment will be conducted and compared to previous works.

2 SCHEME DESIGN

2.1 Site Walkover

Green Cat Renewables (GCR) conducted a site walkover to assess the buildability of the Glenachulish hydro scheme. The scheme is located in Forestry Commission ground. During the visit the intake location, the route of a pipeline and the sighting of a powerhouse were assessed. There are a number of existing access tracks that the project can utilise for delivery and construction vehicles. A small new section of track is required from the existing access to the intake location. The lower section of the pipeline above the powerhouse is quite a constrained location as the working area is less than 10m wide between a steep slope which drops in the river and a third party land boundary. The access track is located within this working corridor and the pipeline will need to be installed either under the ditch or below the track surface. Within the site there is a disused Scottish Water intake and pipeline which used to supply the village. This infrastructure has been decommissioned but the pipeline is still in place so it is highly likely there will be conflicts between the hydro scheme and this pipeline. A significant area of plantation will need to be felled to allow construction. There are also a large number of mature trees to fell within the powerhouse area.

2.2 Scheme

The designed power output of the scheme is 544kW. The available power from a hydro scheme is directly proportional to the height difference from the intake to the powerhouse as well as the available flow of water. Due to the forestry on the site a GPS topographical survey (topo) has not been undertaken, so head and pipeline lengths have been deduced from map data. Therefore the figures used are not as accurate as onsite measurements. The intake location has been confirmed, no higher location is available due to the topography banks of the burn, which become very high. The pipeline can be laid from the intake location relatively easily. It follows a new section of track and intersects with the existing access and crosses it into the forestry on the far side. The proposed pipeline is 1,335m long and has been designed as DN600 ductile iron for pressures up to 11bar.

The powerhouse is located at the lowest elevation possible within the Forestry Commission ground. The building will contain the turbine, generator, control panel, switchgear and all the necessary lifting equipment. The abstracted water is returned to the river via a tail race. The structure is designed to suit the local vernacular. The powerhouse has high levels of noise insulation due to its location close to residential buildings.

2.3 Access

The scheme has a traffic management plan that has been agreed as part of the planning permission for the delivery of materials and vehicle access. All heavy goods vehicles must access the site from the A82 via an existing forestry road. Light goods vehicles are permitted to access the site from the A828. The forestry road is in good condition however, there is one sharp inclined corner which is likely to pose an issue to articulated lorries. This may require materials to be off loaded and transferred to another vehicle. Rigid body trucks will be able to negotiate the corner so concrete wagons will be able to access the powerhouse and intake. It is likely that special permission will be required and sorted for the turbine delivery.

3 HYDROLOGY

3.1 CAR Licence

The CAR Licence (CAR/L/ 1138676) for impoundment and abstraction was approved on the 3rd of February 2016. This sets the limits of abstraction, minimum compensation flows, location and dimension of structures, location of discharge and special conditions.

The total allowed abstraction is 610l/s. The following conditions are also defined in the CAR licence (Note: the Q(X) is the flow rate that is exceeded during X% of the year):

- Abstraction can only start when the flow upstream of the intake is equal or greater than 54l/s but only when the flow immediately downstream of the intake is greater than or equal to 54l/s).
- The flow that must be delivered downstream of the intake when the flow upstream of the intake is greater or equal to 477l/s (Q(30)) is 82l/s).

3.2 Flow Monitoring

A hydrology report was produced by MNV Consulting in March 2015. This report assessed water level data and manual gaugings collected between April 2008 and April 2010. A flow monitoring station including a data logger which records water levels every 15 minutes was set up on the 18th of April 2008. Data was recorded during 24 months and 14 gaugings were taken within that period of time. The result is a recommended long term design Flow Duration Curve (FDC).

The assessment was carried out by a company with broad experience in flow gauging and hydrology assessments. The methodology described in MNV's report is acceptable, however there are a few issues that are worth mentioning.

The control section in which the logger was installed had a considerable amount of sediments (including stones of many different sizes on the river bed). This is an issue as sediments can move, changing the shape of the control section and affecting the reading of the water level. This was identified by MNV when the stage-discharge curve was plotted. MNV concluded that the only data that could be used was the data recorded between October 2008 and September 2009. The R-squared value associated to the trend-line that best fits the aforementioned curve was not provided as a number but, based on figure 2 of MNV's hydrology report (March 2015), it would stay within normal numbers. The error associated with this approximation will be taken into account as uncertainty further in this report. It is important to mention that Green Cat Renewables has not reviewed the raw flow monitoring data and therefore is it not responsible for any errors in MNV's assessment derived from processing such data.

Three flow monitoring stations were selected by MNV as best analogue to the catchments at the flow monitoring station. These were Claggan, Polloch and Glenstrae. Claggan and Polloch are within the top 3 scores according to SEPA's analogue tool however Glenstrae does not appear. Thus, Glenstrae's FMS was discarded. As the final FDC was defined as the average of the three Re-scaled long term FDC (one for each FMS) we produced a new final long term FDC as the average of the Re-scaled Claggan and Polloch FDC. The resulting FDC is the following Table 3.1 - GCR design Flow duration curve at the FMS:

Table 3.1 - GCR design Flow duration curve at the FMS

Exceedance	Re-scaled Claggan	Re-scaled Polloch	Final long term FDC
5%	0.774	0.796	0.785
10%	0.692	0.596	0.644
15%	0.534	0.481	0.508
20%	0.454	0.421	0.437
25%	0.375	0.344	0.359
30%	0.311	0.273	0.292
35%	0.276	0.237	0.257
40%	0.243	0.201	0.222
45%	0.198	0.182	0.190
50%	0.156	0.147	0.151
55%	0.126	0.115	0.121
60%	0.110	0.098	0.104
65%	0.090	0.085	0.088
70%	0.079	0.072	0.076
75%	0.058	0.059	0.058
80%	0.042	0.044	0.043
85%	0.028	0.031	0.029
90%	0.019	0.020	0.019
95%	0.011	0.011	0.011

3.3 Low Flows 2

"Low Flows 2" is software (LF2) developed by the Centre for Ecology and Hydrology at Wallingford. SEPA and the Environment Agency accept the use of this software for small ungauged catchments in the UK. The river of this project accounts with flow monitoring data however we estimated a LF2 FDC to compare with the results from flow monitoring. The aim is to find if there are significant discrepancies that can indicate an error in flow gauging.

The software provides long term average flow estimates. To do this, the software scales and factors the data from analogue Flow Monitoring Stations (FMSs) by variations in catchment size, rainfall, and terrain characteristics with a user defined catchment. The level of uncertainty associated to small catchments in Scotland is 11%. See LF2 FDC in Table 3.1 - GCR design Flow duration curve at the FMS.

3.4 Flow Duration Curve

Each flow of the FDC at the FMS was multiplied by a ratio equal to catchment area at intake/catchment area at FMS. Thus, the design FDC at the intake location, based on the results of flow monitoring, can be estimated. The resulting FDC is shown below in Table 3.2 - LF2 FDC and GCR design flow duration curve at the intake and in Figure 1 - LF2 and Design FDC.

Table 3.2 - LF2 FDC and GCR design flow duration curve at the intake

Exceedance	LF2 FDC at intake	Design FDC at intake
5%	1.682	1.230
10%	1.161	1.010
15%	0.881	0.796
20%	0.700	0.686
25%	0.564	0.564
30%	0.463	0.458
35%	0.382	0.403
40%	0.319	0.348
45%	0.265	0.297
50%	0.222	0.237
55%	0.188	0.189
60%	0.158	0.163
65%	0.133	0.137
70%	0.113	0.118
75%	0.095	0.092
80%	0.080	0.067
85%	0.066	0.046
90%	0.053	0.030
95%	0.039	0.017

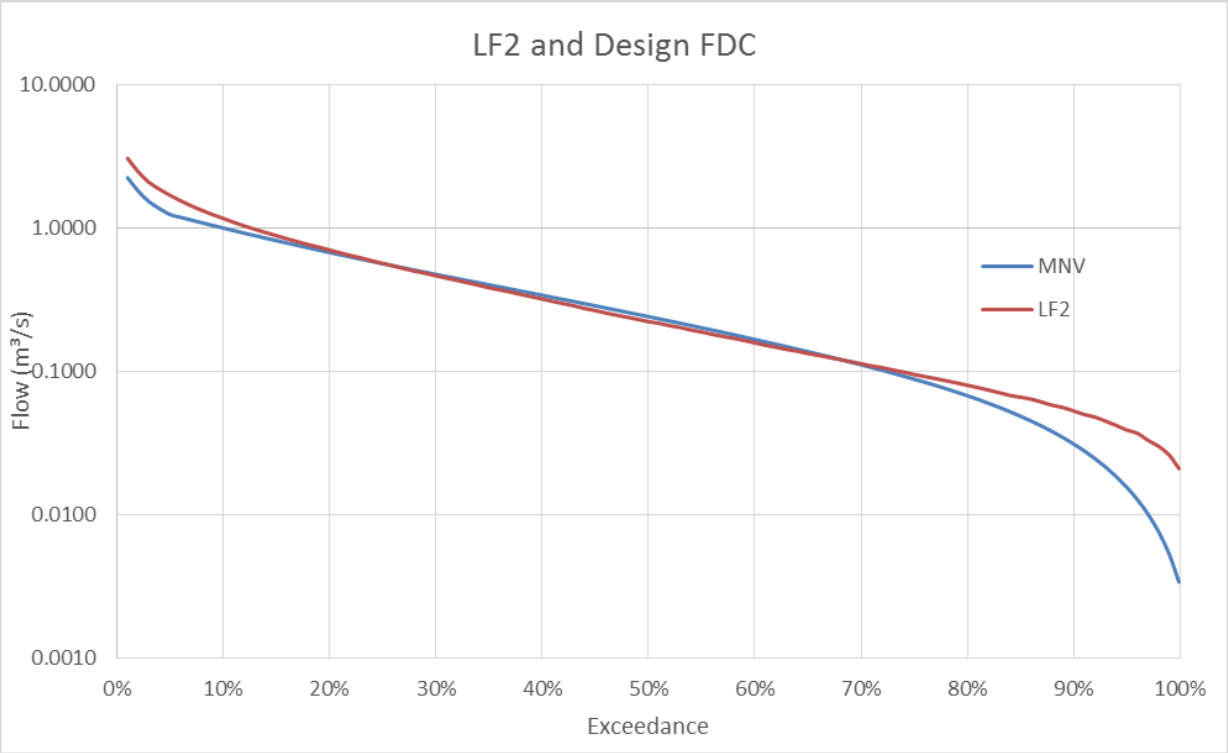

Figure 1 - LF2 and Design FDC

It is clear from the graph that high flows and low flows are higher in LF2 FDC than in the design FDC. Both FDC follow a very similar pattern in the mid flows, which are the most relevant for energy generation. Due to the turbine characteristics and compensation flows the scheme should not generate below Q(70) and it would be generating at maximum power above Q(20). Both curves shown in figure 1 have a similar pattern between Q(20) and Q(70) therefore it can be concluded that, for the purposes of this assessment, the results of flow gauging are acceptable. As flow gauging, when carried out by competent personnel and following acceptable methodologies, is deemed to be more accurate than LF2, the design FDC derived from this assessment was used for the estimation of annual generation figures.

3.5 Historical Data.

Historical daily flows are available for the Claggan and Polloch FMS. The Claggan FMS accounts with 35 full years of daily flows while the Polloch FMS accounts with 20 years. These flows can be scaled down to estimate daily flows at the intake by applying a ratio equal to Qi(X)/Qj(X). Where Qi(X) is the flow that is equal or exceeded X percent of the year at the intake and Qj(X) is the flow equal or exceeded at the same X percent of the year at the FMS. Long term FDC at the FMS were generated and the percentiles and flows of the design FDC shown in Table 3.2 - LF2 FDC and GCR design flow duration curve at the intake were used to estimate those ratios.

Hence, daily generation figures for 35 years using Claggan daily flows and 20 years using Polloch daily flows can be estimated (see section 8).

4 PLANNING AND CONSTRAINTS

The Decision Letter approving the consent for the proposal was issued on the 23rd November 2016. This unfortunately means that the 3 year time limit, within which the development should have been started is coming to an end. This is the main issue with the current planning consent. Section 58 of the Town and Country Planning (Scotland) Act 1997 states that planning permission must commence within 3 years of the date of the decision notice or the planning permission shall lapse.

LEG and GCR have met with the planner from The Highland Council who has confirmed no extension is available to the project but they would allow a phasing of the pre-construction surveys so a small section of works could start, enabling the planning permission to be initiated before it expires without commencing full works.

Twelve conditions are attached to the planning consent that require to be agreed or discharged before work starts on the site or particular elements commence. Table 4.1 summarises them. All are to be expected for a development of this nature in this location.

Table 4.1 - Condition Summary

Planning consent conditions and comment
Condition 1: Pre-construction surveys: otter, pine marten, bats, red squirrels, water voles, wildcat, badger and breeding birds.

Green Cat comment and reason for condition: This condition is to protect protected species and is completely standard for this type of development. It requires submission of survey work and approval.

Original ecology surveys for planning consent were undertaken in 2014/15. The pre-construction surveys will be carried out in 2019. Given the length of time that has passed, potentially the number of protected species using the area or how and/or where they are using the area may have changed.

No bat survey has been undertaken in the preplanning phase, although a potential roost has been identified in the powerhouse area where mature trees offer bat habitat.

Given that a significant number of trees are proposed to be felled in this location, there will potentially be cost implications in commissioning a licensed bat expert to assess any roost and give specialist advice if the roost is in a tree proposed to be felled or nearby. This may also cause a time delay. The Ecologist is aware of this potential issue.

No mention in this condition of eagles and other raptors. The site is situated between two SPAs. SNH did not consider this to be a problem as eyrie 3kms away. However if the eagles have moved into area or fly over, their presence can halt construction for months.

Condition 2: Development shall be carried out in accordance with submitted reports or their update.

Green Cat comment and reason for condition:
This condition is to ensure the development is implemented in accordance with what has been approved and is completely standard.

3. 2 months before commencement of any works a Construction Environmental Management Plan shall be submitted to the planning authority and SEPA for approval. It will incorporate:

- Peat Survey
- Micro-siting to avoid deep peat
- Mitigation for peat and GWDTEs
- Floating tracks
- Excess peat
- How felled trees are to be used
- A finalised CMS
    - No borrow pits. Details of alternative source to be given
    - No blasting, no helicopters
    - Details of finished treatment of area around power house
    - Final site decommissioning

Green Cat comment and reason for condition: This is a standard condition that requires submission of info and approval. An issue might be lack of borrow pits in consented application. The appointed ECoW will be involved with micrositing and mitigation.

Condition 4: Appointment of ECoW
Green Cat comment and reason for condition: Reason for this condition is to provide appropriate expertise to ensure best practice and approved construction and mitigation techniques are carried out. On a development of this nature the requirement to appoint an ECoW is completely standard and to be expected. Working alongside the contractor, problems or issues that arise can be dealt with quickly with minimal impact. The condition requires the appointment of the ECoW to be approved by the Planning Authority. The ECoW to be appointed at the relevant stage will be Kate Proctor of Highland Ecology. Kate is an experienced ECoW, and has worked with GCR, The Highland Council and the SNH area team on other hydro developments in the locality.
Condition 5: No trees to be felled (other than those specifically identified) or damaged in any way without prior permission of the Planning Authority.
Green Cat comment and reason for condition: Standard condition where there are trees onsite and felling is necessary.
Condition 6: Protection of retained trees.
Green Cat comment and reason for condition: Standard condition to be agreed and carried out. Specific barriers not tape are to be used (Heras fencing) for protection beyond the Root Protection Area. ECoW advice will be taken on this issue.
Condition 7: Tree Planting Plan & Maintenance Programme to be submitted for approval by the Planning Authority before development, site excavation or groundwork commences. An equivalent amount of tree planting shall be undertaken to that felled.
Green Cat comment and reason for condition: Standard condition where trees are concerned. Ongoing costs with this, removing damaged replanted trees, replacing etc as per the Maintenance Plan that is to be written, submitted and approved. There is information for tree replanting in the document APDX_C_Aboricultural Impact Assessment. The plan for the powerhouse area isn't mapped in detail although species of trees proposed to be planted is given. The ECoW will create the planting plan and maintenance programme.
Condition 8: Construction traffic and timber lorries and machinery required to fell forestry shall access the site in accordance with the approved Traffic Management Plan: Appendix I of the ER. – no HGV's to access site via A828 U1598 Glenachulish Road

Green Cat comment and reason for condition: This essentially means that no HGVs can access the site via the A828 and U1598 Glenachulish Road.

May be added costs as HGVs will use a longer forestry road into the site that will have to be maintained etc.

Condition 9: Public access to any Core Path within or adjacent to the site shall at no time be obstructed by construction related activities unless approved in writing by the Council's Access Officer (in conjunction with FCS) as a temporary measure for health and safety or operational purposes. Under such circumstances, any temporary obstruction shall cover only the smallest area practicable and for the shortest duration possible, with waymarked diversions provided as necessary.

Green Cat comment and reason for condition: This is a standard condition where construction site affects a Core Path. There are two core paths in area. Both access routes follow forest roads that are core paths. Penstock will cross one of these. Forward planning will be essential by the Contractor and Client Engineer to avoid any delays while seeking approval from the Council's Access Officer if it is necessary to temporarily obstruct any Core Path. Fencing may be required to keep Core Path users safe. Clear signage giving forewarning of the construction site and any diversions will definitely be required.

Condition 10: Powerhouse materials as per drawing no.20053-DRG-202 Rev. P2, to be used unless written approval is given for other materials.

Green Cat comment and reason for condition: Standard condition.

Condition 11: Two different noise standards are outlined to adhere to NR20 or BS 4142:1997.

Green Cat comment and reason for condition: Residential properties are located 80m above powerhouse and 50m below. These noise standards are strict. Note that there is no 'existing or consented' clause concerning dwellings in this condition. Static caravans would also be covered by the noise limits. Theoretically then, the development could move from compliance to non-compliance if someone builds a dwelling or parks a static caravan at a shorter distance than 50m to the powerhouse. We would recommend clarifying this scenario with the Planning Authority.

Condition 12: Full details of powerhouse and outfall noise attenuation measures to be submitted for approval by Planning Authority.

Green Cat comment and reason for condition: Due to the nearby dwellings the design of the powerhouse will require to have effective noise attenuation measures incorporated into its design. This will increase the cost of the powerhouse in comparison to more isolated schemes.

5 GRID CONNECTION

5.1 Offer

An Offer Letter for a Distributed generation for the Greadhain Hydro project was provided, by SHEPD to Green Highland Renewables, on March 2019 and subsequently accepted on the 26th of March 2019. It is noted that this offer letter was issued after two other offers were made by SHEPD, back in 2011 and 2014. The 2011 offer concerned a connection of 500kW and the 2014 offer concerned a 200kW additional connection to the previous offer. With the acceptance of the 2019 offer, it supersedes these two previous offers, 2011 and 2014, as mentioned in Clause 12.1.1 in the 2019 Grid Offer letter. Upon accepting the offer, Green Highland Renewables has paid the first payment of £12,302.40 (Incl. VAT at 20%) to SHEPD. The Second payment of £70,251.60 (Incl. VAT at 20%) is not due until 31st October 2019.

Under this agreement, Greadhain hydro has an export capacity of 700kW with an import capacity of 15kVA. The power factor range between 0.95 lag – 0.95 lead at the connection point. The generator operates on a voltage control mode. The connection point is at the hydro site terminals of the SHEPD metering panel.

5.2 Connection Compliance

The design should confirm and demonstrate compliance to the requirements detailed in Engineering Recommendation G59/3. The hydro scheme will need to comply also with both G5/4 Limits for Harmonics and the P28 limits for voltage fluctuations. Note SHEPD will not energise the connection until these studies are satisfied with the connection compliance requirements as mentioned in Clause 17.2 of the 2019 Grid Offer letter. These studies are standard for a hydro scheme of this size. The cost for the studies will be in the range of approximately £10,000 and it is not included in the price that SHEPD has proposed in Clause 3.1, because it is up to Greadhain Hydro to provide these studies to SHEPD.

5.3 Right to Remain Energised

With the site due to be energised in the first quarter of 2021, some parameter and control systems must be in place to ensure the security of the connection. Failure to comply would give SHEPD the right to switch off the site. Under this agreement there are technical parameters that the user must comply with. These are the import and export capacity values, voltage control (power factor operation) and the systems operating frequency. These are typical requirements for any hydro scheme.

Apart from the technical aspect, there is the requirement to have an energy supply provider, meter operator, and PPA provider in place for export to the grid. They also require all outstanding payments for the connection to have been completed and all technical parameters.

6 CAPITAL COST

The total estimated capital cost is **£1,728,482** (see Appendix A for details) and considers the following:

6.1 Civil Costs

This is the estimated budget to carry out all civil works by a competent contractor. We have defined the main construction units and materials and priced them based on GCR cost records. We assumed the most cost-effective design that does not compromise performance and safety and that minimised the impact to the environment. We considered the project programme and highlighted the potential environmental constraints to ensure the budget is realistic with these conditions. In addition, additional work rates for those riskier items have been included. Costs of personnel, machinery and materials are influenced by several factors such as: proximity of contractor to site; market; season in which works are carried out; distance to transport imported materials; contractor's expertise; contractor's workload; fuel prices; other. Thus, this budget must be taken as a good estimation based on pre-tender information and detailed budgets should be requested to contractors during the tender stage.

The total estimated civil cost excluding contingency is £910,470 (see Appendix A).

6.2 Additional Construction Costs

These costs account for construction units and items that are not included in the civil costs as well as rates of those units that have a risk of exceeding their estimated quantity.

- Rock breaking for structures: It is not expected to have large amounts of rock breaking however, as there is no information about ground conditions, there may be some rock breaking to deal with. Contingency, as 10% of the pipe trench and an additional 200m³ for the main structures, was included in the civil costs. Any additional rock breaking can be expected to be priced at £65/m³.
- Imported stone: There are no borrow pits approved in the planning permission and there is no sign of "active" borrow pits/quarries nearby. Therefore imported stone will be needed for the pipe trench, roads, laydown areas and maybe for the structures. We have included imported stone in the pipe trench and access tracks however, more stone may be required. In that case, it can be expected to be priced at £40/m³
- Electrical ancillaries at the powerhouse: This is for the design, provision and installation of the electrical items required at the powerhouse (lighting, heating, fan, earthing and all electrical connections). It was priced by Prelec as £50,000.

6.3 Contingency

Contingencies have been added to the construction works, appropriate to the predicted level of cost risk of the element or activity. The range of cost risks we have accounted for comprise the following:

- Unknown ground conditions.
- Weather related delays.
- Risk of final detailed design cost rising from initial estimated cost.
- Material cost variation.
- Delays from delivery of prefabricated pieces, turbine or other items.

Contingency is applied to each different unit and accounts for a total of £147,538 (14.59% of the civils & electricals).

6.4 Turbine, Generator and Control Panel

We have gone to two different manufacturers for pricing. The best offer in terms of quality and price is the one provided by Hydrohrom. We have previously worked with them and have built a good relationship. The quality and service of their product has been satisfactory so far. The latest offer is for a 544kW Pelton including generator and control panel at a cost of €332,404 which is approximately £305,000 (This cost could vary slightly with changes in the Euro/Pound exchange rates). The following Table 6.1 - Specification Summary details the main technical parameters of this turbine and generator:

Table 6.1 - Specification Summary

Turbine Summary	
Gross head (m)	111
Net head (m)	106.3
Maximum turbine discharge [QTmax] (m^3/s)	0.610
Minimum turbine discharge [QTmin] (m^3/s)	0.030
Turbine output (kW)	573
Generator output (kW)	544
Turbine speed (rpm)	600
Generator speed (rpm)	600
Diameter of runner (mm)	610
Number of nozzels	5
Generator type	Synchronous
Generator's nominal output (kVA)	600
Nominal voltage (V)	400
Frequency (Hz)	50

6.5 Additional Project Costs

The additional project costs to be considered are the following:

- Grid connection: Offer received from the DNO for a total of £109,803.51.
- Consultancy fees (Green Cat Renewables ltd): The design and management of the project was estimated to cost £159,935 (see Appendix B).
- Legal costs. This accounts for the legal assistance required to put the contracts in place and is estimated as £20,000.
- Insurance. Estimated as £12,000.
- Ecology: This is for commissioning an ECoW and undertaking surveys as required by the planning conditions attached to the consent. It has been estimated as £10,000.
- Due diligence: This is only required if bank finance is sought and accounts for a revision of the project by an independent consultant. The costs for this will be in the region of £20,000.

The total price of this is £331,739.

7 OPERATION COST

The estimated annual operational costs are the following:

- Lease: Assumed as 10% of revenue. £22,218 per annum based on the P50 at 111m gross head.
- Metering charges: This accounts for £250 and includes the fees to rent the metering equipment required to measure the import/export of electricity.
- Electricity: £1,000 as an estimation of the required imported electricity from the grid to supply the loads in the panel and hydraulic pump plus other electrical appliances at the powerhouse when the scheme is not operating.
- Maintenance and professional fees: This includes cleaning the screen which is carried out with more frequency during the summer. This river may accumulate large quantities of slime on the screen. Cleaning every week during the summer and monthly during the winter; monitoring performance (on a daily basis at least for the first year, including a detailed assessment of generation); checking the state of the civils (once a year); and maintaining the electromechanical equipment (greasing and cleaning every year, cleaning dust and inspecting the powerhouse for noises every two weeks), estimated as £10,000. This has to be revised after the first year as it can vary depending on the scheme performance. If the community is involved at "zero charge" for that part of the maintenance and they could do some training, this cost could be significantly reduced.
- Non-interest bank charges: This has been estimated as approximately £2,500.
- Rates: This accounts for the business fees to be paid to the government for the revenue obtained. It is estimated as 10% of the annual revenue therefore it varies with the generation figure considered. There is a risk this fee exceeds 10% for which contingency has been included. Approximately £20,000 for a P50. Community schemes can apply for rates relief however banks/lenders to not take this in to account for financing modules.
- Contingency: estimated as £2,000 to cover for unforeseen costs and uncertainties.
- SEPA annual fees: Approximately £200 a year.
- Insurance: This has been estimated as £6,000 a year and applies during the length of the loan only in the case of bank finance.

The total operational cost based on an annual average generation (P50) is:

- 111m: £66,385
- 116m: £68,521
- 106m: £64,250

8 ENERGY YEILD ASSESSMENT

8.1 Available Head

As a topographic survey is not available and the GPS levels taken during the site visit are not reliable because of a weak signal due to tree covering, the gross head was estimated as 111m as per Green Highlands environmental report. An analysis of the contours and the GPS levels taken on site suggests this head is likely to be achievable. However, as there is no reference of the methodology used by Green Highland to estimate the gross head, we have considered two additional cases with +/-5m gross head for comparison.

8.2 System Efficiencies

Head losses

GCR modelled the head loss in the pipeline using the Haaland revision of the Colebrook-White transition formula. The pipeline is estimated to be approximately 1,335m long and 700mm internal dimeter. This gives the following pipeline losses due to friction and turbulence (contingency applied to account for turbulence due to fittings):

1. 111m head – 9.3%
2. 116m head – 8.9%
3. 106m head – 9.7%

Turbine and generator efficiencies

The possible turbine types for the combination of head and flow are a Pelton, Turgo and Francis. A slow Pelton machine was selected in this assessment. Efficiencies of a turbine and generator from the selected turbine offer were introduced in the model. The selected efficiencies of the generator were those achieved under 0.95 power factor.

8.3 Fixed Losses

Additional fixed losses are accounted for in the net generation estimate. They are estimated and comprise 2% hydro system downtime and 2% grid downtime equating to 4% for total, additional fixed losses.

8.4 Base Average Annual Electricity Production Results

The baseline average annual electricity production (AAEP) results were modelled using the full record of scaled daily flows at the Claggan and Polloch FMSs. Generation was modelled for each day. Then, annual generation for each year was calculated. The average of all years is the average annual generation (P50) for each FMS and the average of the P50s of each FMS is the project's final P50.

The power output, P_{out}, for each day, is calculated:

$$P_{out}(kW) = \frac{H_{net} \cdot Q_{used} \cdot \eta_t \cdot \eta_{gen} \cdot g \cdot \rho_w}{1000}$$

$Where$:

H_{net} *is the net head* (m)

Q_{used} *is the flow rate used* (m^3/s)

η_t *is the turbine efficiency* $(\%)$

η_{gen} *is the generator efficiency* $(\%)$

g *is the gravitational constant assumed to be* $9.81 m/s^2$

ρ_w *is water density constant assumed to be* $1{,}000 kg/m^3$

The maximum power output for each case is the following:

1. 111m head - 540kW
2. 116m head – 567kW
3. 106m head – 513kW

The P50 or AAEP is the level of annual electricity generation expected to be equalled or exceeded in 50% of years. The AAEP is then calculated from:

$$AAEP\ (MWh) = \frac{P_{out,avg}\ .\ 24\ .365}{1{,}000} \times (1 - fixed\ losses)$$

AAEP for the three cases resulted in the following:

1. 111m head – 1,897MWh
2. 116m head – 1,989 MWh
3. 106m head – 1,806 MWh

8.5 P90

The P90 generation output is the estimated value which has a 90% probability of exceedance over a defined period of time; be it a year or a number of years. It is useful for this type of project to estimate:

- P90 over any 1 year;
- P90 over 10 years [a typical loan period]

As assessing the variability of generation over time is required, modelling this requires the use of historical flow data. Historical daily flows at the Claggan and Polloch, both inclusive, were used.

Finally, a series of uncertainties, which are described further in this section, are taken into account together with the variability of generation in the calculation of P90.

Standard deviation

The probable value of measurable natural events, such as river flow, tend to follow a statistically known pattern called a normal distribution. In the calculation of variability, a 90% exceedance equates to approximately 1.28 standard deviation below the mean when a normal distribution is assumed.

A calculation of the n-year standard deviation in AAEP can be made based on the long term flow data available, which calculates how far measurements tend to deviate from the long term average. This is:

$$\sigma_{per} = \sqrt{\frac{\sum(AAEP - \overline{AAEP})^2}{(n-1)}}$$

σ_{per} *is the standard deviation*

n *is the number of observations in the sample*

10 year standard deviation

The standard deviation of the AAEP calculated from the modelled annual generation is the calculation of variation from the average in any one year. To calculate the 1 year 90% exceedance:

$$\sigma_1 = 1.28 \times \sigma_{per}$$

where:

σ_1 *is the* 1 *year* 90% *exceedance level*

To translate this into different timeframes, the equation below is used, where the standard deviation, σ_N, over a set period, N, years is:

$$\sigma_N = \frac{\sigma_1}{\sqrt{N}}$$

This enables the conversion of the 1 year P90 exceedance to a 10 year P90 exceedance. Table 8.1 below summarises the results.

Table 8.1 - 1yr and 10yr P90 exceedances

Case	1 year P90 exceedance	10 year P90 exceedance
111m head	16.90%	5.35%
116m head	16.92%	5.35%
106m head	16.89%	5.34%

Uncertainties of generation

Uncertainties are factors that can result in generation estimates differing from the predicted exceedance value. The resulting value can be positive or negative, however for assessing 1 and 10 year generation only the average generation less the uncertainty is considered.

The main uncertainties associated with this assessment are: flow measurement error; stage-discharge accuracy; correlation with FMS; FMS sensitivity; FMS data calibration.

As we have not participated in flow gauging and we have not assessed the raw data, it is hard to estimate the uncertainties associate with this. However, as MNV are deemed to be experts in the field, it has been assumed flow gauging was carried out under good quality standards. A 3% uncertainty level has been applied to account for errors during data processing of the final FDC.

Regarding the FMS daily flows. The data obtained was calibrated by SEPA, the records are complete and do not show any unusual patterns. The sensitivity of the FMSs is low compared to the average of all FMS in Scotland. Due to the nature of the FMS and based on our experience, it has been assumed that the uncertainties in this FMS are low. GCR assumes a maximum uncertainty equal to 3% as contingency.

The individual variations and uncertainties are calculated using the root sum square (RSS) method. The total uncertainty results in 4.24%. Table 8.2 below shows the final combined RSS uncertainties (including uncertainties and standard deviation).

Table 8.2 - 1yr and 10yr P90 combined RSS exceedances

Case	1 year P90 RSS combined exceedance	10 year P90 RSS combined exceedance
111m head	17.43%	6.83%
116m head	17.44%	6.83%
106m head	17.41%	6.82%

8.6 Results

Table 8.3 summarises the results:

Table 8.3 - P50 and 1 year and 10 year P90 generation

Case	P50 (MWh)	1 year P90 (MWh)	10 year P90 (MWh)
111m head	1,897	1,567	1,768
116m head	1,989	1,642	1,853
106m head	1,806	1,492	1,683

9 REVENUE

Revenue is the product of the £/MWh multiplied by the total energy generated (MWh). The total energy generated depends on the power output and the amount of hours that the scheme has been in operation.

The main sources of income that this scheme will benefit from are the selling price of electricity (assumed as an average of £55/MWh) and the FiT secured through pre-accreditation (£62.1/MWh). OFGEM pre-accreditation has been submitted and currently valid till 26th of March 2021. Once this is transferred to the community company then additional 6 months will be to the validity period.

Table 9.1 provides a summary of the gross average annual revenue for the three cases:

Table 9.1 - Summary of annual revenues

Case	P50	1 year P90	10 year P90
111m head	£222,177	£183,453	£207,012
116m head	£232,854	£192,233	£216,951
106m head	£211,499	£174,672	£197,072

10 ECONOMICS

At this stage three economic summaries have been produced for each head level (111m, 116m, 106m). These are shown in Appendix C. The 20 year IRR at 10 year P90 Revenue range between 7.89-9.26% which is considered excitable for a hydro project. The next stage is to discuss potential routes to funding for the project. This can be bank or non-traditional funding methods such as a community share offering. A CARES financial model will then be produced to evaluate different funding options.

11 RISKS AND PROGRAM

This section presents a summary of those risks that could affect the viability of the scheme and should therefore be mitigated. These risks are detailed in Table 11.1 - Risk Summary below. The updated program is provided in Appendix D. The program is based on discharging conditions as soon as possible, minor works being conducted to initiate planning and achieve land rights and financial close in 6 months' time.

Table 11.1 - Risk Summary

RISK ID	RISK	MITIGATION
1	No borrow pits permitted in the planning application.	Negotiate the possibility to obtain stone from old borrow pits/quarry in Forestry Commission land. Identify the nearest quarry that can supply the amount of stone required and obtain costs per m^3 of material.

2	HGV access to intake and upper section of pipeline through FC existing access. This has to be negotiated with the FC and there may be potential fees involved/road maintenance. There is a risk the FC does not allow HGVs along their tracks during construction at times but because of other activates they are undertaking.	Negotiate the possibility to use FC access tracks with the conditions that traffic will not affect their operation and the track will be reinstated after construction. Investigate the possibility of inaccessibility to the FC tracks and ensure the contractor is aware of this. If it is not possible to avoid fees, re-assess the economics including these fees. If a fee applies to the use of FC access, negotiate compensation for those times the access could not be used.
3	Tree felling is required not just at the powerhouse location but in FC land and access from powerhouse to forest. The costs of this are uncertain. Planning condition 7 requires that an equivalent number of trees are to be planted that are being felled. The Tree Planting Plan should fit in with the Forest Plan for the planation as a whole.	Negotiate with the FC a cost for felling all trees and any planting required. Re-assess the economics including any additional costs. Check with a contractor the cost of felling the trees if there are any not standard conditions imposed by the FC. Check with contractor the cost of felling trees at powerhouse location. There are a number of mature trees here.
4	Bats – no bat survey undertaken in planning submission documents but a potential bat roost is marked on area of powerhouse location. If bats are in a tree to be felled or would be disturbed if an adjacent tree is being felled this may incur costs and delays.	Recommend to seek advice from a licenced bat expert regarding any likely timescales and processes that would require to be adhered to in these circumstances.
5	Core Paths – site affects two core paths. Any obstruction of them could add to work delays and costs.	Approval must be sought for temporary obstruction. Signage and safety paramount for Core Path users.
6	Noise – strict noise standard.	Clarify with Planning Authority if noise condition compliance will also apply to any new noise sensitive premises that may locate closer to the powerhouse in the future. High level of noise mitigation required within the powerhouse structure.
7	Age of ecology surveys – conditions and protected species using the area may have changed from 2014/15 to 2019 by time the preconstruction surveys are undertaken.	Seek the opinion of an ecologist and SNH and carry out any necessary new surveys.

8	Eagles have an eyrie 3kms away. SNH didn't think this was a problem as site doesn't provide good eagle feeding habitat. However if an eagle is spotted over the site this could delay work.	Ensure the contractor is aware of this prior to tendering. The programme should allow the contractor to work if this occurs without major consequences to deadlines and costs. Mitigation required from the contractor at tender stage. Ensure delay costs are included in the contract.
9	Construction width corridor is stated as being up to 15m. This is to include access track, area for storing turves etc, penstock and drainage. This is tight in sections.	Ensure the contractor includes a construction methodology that is suitable for a 15m corridor. Excavate, lay and backfill the ductile iron sections one by one from the powerhouse towards the intake is an option.
10	Access to be maintained at all times to the cottages close to the powerhouse location. The pressurised pipe and outfall pipe both cross the access to these dwellings. In addition the Forestry car park is to be used temporarily for the main compound. As this is a well used car park, two parking spaces are to be kept available for the public. This may cause problems of safety and logistics.	Ensure the contractor is aware of this and includes a way to provide access to the cottages during construction in the method statement. Carpark – ensure contractor is aware of this and plans accordingly with positioning of compound and makes provision for the continuing availability of two parking places to the public.
11	Private water supply taken from the burn that serves residential dwellings and hotel (read in Planners Report of Handling). If burn affected during construction, could be very costly to supply water to these properties.	Ensure the contractor is aware of this and includes suitable silt management measures and action plans against unforeseen events that could compromise those measures.
12	FC land in use. Potential fees not confirmed. This could be expensive.	Negotiate a lease cost with the FC and revise CAPEX/OPEX.
13	GWDTEs – survey very general. It may be required to be undertaken to today's standards if SEPA and Planning Authority want clarification of micro siting.	Allow contingency for a new survey in case this is required.
14	Rock breaking. Contingency for rock breaking has been included in the CAPEX however, as there is no ground information, there is a risk this is more than expected or harder to break. Additional rock breaking is expensive.	Carry out a site investigation at key locations prior to tender stage.

15	OPEX is quite project specific and some of the costs depend on the type of finance. Variation in the OPEX have a high impact in the NPV and IRR.	Define finance methods and consequent annual costs. Confirm as many operational costs as possible and re-assess the economics.
16	Head – Topo survey to confirm working head level	Conduct survey at powerhouse and intake to confirm levels and thus reduce uncertainties around energy production levels
17	Planning permission validity period	Discharge conditions and start works before the end of the validity period. This can be restricted to a small section of the site works.
18	Land rights. The forestry commission are notoriously slow to reach agreement on land rights.	Ensure program has slack within it and that a push for small section of project can be build out with the full land agreements e.g. laydown area or bell mouth.

12 FINDINGS AND RECOMMENDATION

The results of this assessment indicate that the Glenachulish hydro scheme is a viable scheme and the risks of the annual generation being lower are low.

Hydrology is normally the main source of uncertainty in the estimation of annual generation. The hydrology is solid and the long term calculations use historical data from several FMS and go back up to 35 years. Thus the uncertainties on the estimation of water resource are low.

The head is another important parameter affecting annual generation as it is key to achieve the estimated power outputs. There is no accurate information of the levels at the powerhouse and intake that allow a precise estimation of the gross head. However, three cases that are deemed to cover the variability of possible heads were assessed and all of them showed good results but it is recommended that this a fully clarifier.

Regarding the CAPEX, the main costs involved in the CAPEX have been confirmed by requesting formal offers and those that are estimations include appropriate contingency. There is a risk in items such as imported stone or tree felling and in potential delays caused by the Forestry commission or the owners of the several services affected by the project. Leasing from third parties is more difficult to quantify than direct project costs although contingency has been added to them, there is still a risk they cost more.

OPEX, it has been estimated. The risky units are the fees to the Forestry Commission and bank charges. As access to the intake during construction has to be done through FC land, there is a chance they will charge for it. The maintenance costs could be brought down if the community is involved in the maintenance of the intake, other structures and mechanical equipment at the powerhouse.

In case of proceeding, GCR recommends to carry out a professional topographic survey to locate the intake and define the gross head. In addition, a site investigation, peat probing and proposal of borrow pits to the planning authority is highly recommended (alternative is to ask the FC about unused borrow pits or seek the nearest quarry and obtain costs). It is also important to define the costs to the FC, including tree felling and plantation. Finally, at the tender stage, it is recommended to take a contractor/s to site to assess the project and discuss areas of potential savings and provide a CAPEX. The production of a CARES financial model for the project.

APPENDIX A – CAPEX

GCR Glenachulish CAPEX

Pipeline	Source	Unit cost	Unit	Quantity	Base Cost	Contingency level	Contingency	Itemised construction cost excluding contingency
Natural Biozinalium Rapid Socket & Spigot 600x6000 C30 Cement In Zn/Al(Cu) Blue Out	Saint Gobain quote	£167.34	metre	1335	£223,399	5%	£11,170	**£223,399**
Pipe laying and reinstatement cost	GCR recorded rate. Imported stone	£120.00	metre	1335	£160,200	20%	£32,040	**£160,200**
Rock breaking	Estimated as 10% of trench	£65.00	m^3	210	£13,641	20%	£2,728	**£13,641**
Total pipeline material cost								**£223,399**
Total pipeline placement cost								**£173,841**
Total contingency on pipeline works							**£45,938**	
Other construction works								
Intake (including screens and acilliaries)	Estimated	£140,000	item	1	£140,000	20%	£28,000	**£140,000**
Upgrading existing access HGV	Estimated	£4	m	3000	£12,000	10%	£1,200	**£12,000**
Upgrading existing access 4x4 (NO HGV)	Estimated	£2	m	870	£1,740	10%	£174	**£1,740**
New access to intake	Estimated	£25	m^2	485	£12,125	20%	£2,425	**£12,125**
Powerhouse	Estimated	£110,000	item	1	£110,000	20%	£22,000	**£102,000**
Tailrace and outfall	Estimated	£12,000	item	1	£12,000	10%	£1,200	**£12,000**
Signal cable (6 pairs)	Estimated	£11	m	1335	£14,685	10%	£1,469	**£14,685**
Pipeline ancillaries; pigging pipework, bends and valves	Estimated	£44,680	item	1	£44,680	10%	£4,468	**£44,680**
Preliminaries	Estimated	£100,000	item	1	£100,000	10%	£10,000	**£100,000**
Thrust blocks	Estimated	£3,000	item	2	£6,000	10%	£600	**£6,000**
Potential additional rock break: intakes, powerhouse and tailrace	Estimated	£65	m^3	200	£13,000	10%	£1,300	**£13,000**
Final reinstatement	Estimated	£5,000	sum	1	£5,000	20%	£1,000	**£5,000**
Tree cutting / removing roots	Estimated	£15,000	sum	1	£15,000	20%	£3,000	**£15,000**
Tree planting	Provided	£35,000	sum	1	£35,000	10%	£3,500	**£35,000**
							Total basic civil cost	**£910,470**
Electrical ancillaries at powerhouse	Estimated	£50,000	item	1	£50,000	10%	£5,000	**£50,000**
							Total basic construction cost	**£960,470**
							Total construction contingency	**£131,274**
544kW Pelton turbine, generator, and control panel	Hydrohrom quote							**£305,000**
Grid connection								**£109,804**
Green Cat Fees								**£159,935**
-								**£0**
Legal costs								**£20,000**
Insurance								**£12,000**
DD								**£20,000**
ECO								**£10,000**
			Total development cost (including contingency)					**£1,728,482**

APPENDIX B – CONSULTANCY FEES BREAKDOWN

Element		Description	Budget Estimate
Phase 1	Review of consents, licensing document and access	Review planning permission, CAR licence, grid connection offer, site access, visit site and conduct walk over of scheme and have meeting with LEG	£1,760
	Review previous resource assessment	Comparison between the MNV hydrology report, Green Highland documents and GCR Low Flows assessment to provide an energy yield for economic assessment. Produce pipeline model	£1,210
	Produce Capital costs (CAPEX)	Produce high-level CAPEX for project using GCR file rates	£975
	Preliminary financial assessment of the options	Use CAPEX and energy yield to assess scheme economics	£415
	Produce showstopper assessment. Risks of developing and mitigations. Project plan and program	Detail risk identified during review with mitigation and impacts on CAPEX. Produce project program.	£845
	Phase 1 report	Collate outcomes from the review and financial assessment in to the phase 1 report	£1,755
	Sub total		**£6,960**
Phase 2	Management, reporting and liaison	Produce and keep up to date programme, budget, risk register and provide client updates	£12,000
	Discharge planning and CAR conditions	Preparation and submission required documents to planning authority and SEPA.	£9,000
	Pre-construction ecology surveys	Surveys required for planning condition discharge	*£1,295 (sub)
	Full system modelling energy yield assessment	Progress energy yield assessment using updated head from topo survey and pipeline model	£4,030
	Topographical Survey	Estimation of sub-contract of topographical survey	*£2,500 (sub)
	Electrical Design and Specifications	Produce electrical design and tender documents as well as liaise with SSE to ensure grid connection is made as programmed	£4,000
	Engineering Design Works	Engineering design of all structures	£11,000
	Turbine tendering	Produce invitation to tender and turbine speciation	£4,000
	Capital and O&M costs	Update CAPEX for the fully sized structures and refine OPEX costs	£5,000
	Detailed economic analysis	Use energy yield assessment, CAPEX and OPEX to for detailed economic analysis	£2,000
	Support for obtaining finance	Support LEG with the CARES financial model	£5,000

	Production of tender documents and management process	- Pre-construction information - Work specification - Pricing schedule - Conditions of contract -Provide LEG with report and recommendation	£12,000
	Construction drawings	Produce all construction drawings and rebar arrangement/schedule	£13,000
	Sub total		**£84,825**
Phase 3	Client Engineer	Contract management during construction phase	£18,250
	Supervision of construction	Regular site visiting to check works conform to design and	£29,000
	Design support during construction	Provide support and produce drawings as required if design variation are made due to onsite conditions or other events	£5,000
	ECOW 12 site visit	Budget price for 6 month construction period which includes 12 site visits	*£5,400 (sub)
	Post commissioning monitoring (6 months)	Download logs and consult with turbine supplier to optimise panel control parameters	£2,500
	Sub total		**£60,150**
Total			**£151,935**

Options		
Peat survey	Peat probing and report (GCG) is required for planning condition 3	£1,500
Geologist attendance	For trial pit excavation (excavator not included)	£650 per day

APPENDIX C – ECONOMICS

Glenachulish 111m- Economics Summary				
P50 base generation (inc. 4% fixed losses)				1897 MWh
10 year P90 generation				1768 MWh
	P50 Revenue	**1y P90 Revenue**	**10y P90 Revenue**	
NPV 20 year	£833,311	£323,896	£633,814	
IRR 20 year	9.61%	6.90%	8.58%	
SPBP	11.1 Years	13.8 Years	12. Years	

Notes
Fixed Losses: 4% deducted from gross generation for grid and turbine downtime
OPEX: Fixed cost of £21,950 plus 2x10% of the year's revenue (10% gov. fee/10% lease)
£10,000 maintenance and professional fees included in the £21,950
Inflation rate: 3% applied to future revenues
Discount rate: Net Present Value calculated using a discount rate of 5%
Bank fees and DD included

Available revenue from FiT and estimated £55MWh sale price	**Revenue £/MWh**
	117.1

Glenachulish 116m- Economics Summary				
P50 base generation (inc. 4% fixed losses)				1989 MWh
10 year P90 generation				1853 MWh
	P50 Revenue	**1y P90 Revenue**	**10y P90 Revenue**	
NPV 20 year	£973,771	£439,396	£764,565	
IRR 20 year	10.31%	7.54%	9.26%	
SPBP	10.5 Years	13.1 Years	11.4 Years	

Notes
Fixed Losses: 4% deducted from gross generation for grid and turbine downtime
OPEX: Fixed cost of £21,950 plus 2x10% of the year's revenue (10% gov. fee/10% lease)
£10,000 maintenance and professional fees included in the £21,950
Inflation rate: 3% applied to future revenues
Discount rate: Net Present Value calculated using a discount rate of 5%
Bank fees and DD included

Available revenue from FiT and estimated £58MWh sale price	**Revenue £/MWh**
	117.1

Glenachulish 106m- Economics Summary				
P50 base generation (inc. 4% fixed losses)				1806 MWh
10 year P90 generation				1683 MWh
	P50 Revenue	**1y P90 Revenue**	**10y P90 Revenue**	
NPV 20 year	£692,841	£208,391	£503,054	
IRR 20 year	8.89%	6.24%	7.89%	
SPBP	11.7 Years	14.7 Years	12.7 Years	

Notes
Fixed Losses: 4% deducted from gross generation for grid and turbine downtime
OPEX: Fixed cost of £21,950 plus 2x10% of the year's revenue (10% gov. fee/10% lease)
£10,000 maintenance and professional fees included in the £21,950
Inflation rate: 3% applied to future revenues
Discount rate: Net Present Value calculated using a discount rate of 5%
Bank fees and DD included

Available revenue from FiT and estimated £58MWh sale price	**Revenue £/MWh**
	117.1

APPENDIX D – PROGRAM

ProjectVision H3831-1057 Glenachulish (02 Aug 2019 16:56)

Task Name	Start Date	Finish Date
02. Review previous resource assessmer	03 Jun 2019	25 Jun 2019
03. Produce Capital Costs (CAPEX)	17 Jun 2019	08 Jul 2019
04. Preliminary financial assessment of th	09 Jul 2019	19 Jul 2019
05. Produce showstopper assessment	08 Jul 2019	22 Jul 2019
06. Phase 1 Report	23 Jul 2019	01 Aug 2019
07. Management, reporting and liaison	12 Aug 2019	11 Aug 2020
08. Discharge planning and CAR conditio	05 Aug 2019	25 Oct 2019
09. Pre-construction ecology surveys (sul	09 Sep 2019	29 Nov 2019
10. Full system modelling energy yield as	26 Aug 2019	12 Sep 2019
11. Topographical Survey (subcontractor)	19 Aug 2019	23 Aug 2019
12. Electrical Design and Specifications	17 Sep 2019	29 Oct 2019
13. Engineering Design Works	17 Sep 2019	09 Dec 2019
14. Turbine tendering	13 Sep 2019	05 Dec 2019
15. Capital and O&M costs	30 Oct 2019	10 Dec 2019
16. Detailed economic analysis	15 Nov 2019	26 Dec 2019
17. Support for obtaining finance	07 Aug 2019	14 Apr 2020
18. Production of tender documents and	28 Oct 2019	06 Dec 2019
19. Construction drawings	18 Nov 2019	07 Feb 2020
20. Client Engineer	07 Oct 2019	07 Feb 2020
21. Supervision of construction	11 Nov 2019	10 Nov 2020
22. Design support during construction	02 Mar 2020	02 Mar 2021
23. ECOW 12 site visit (subcontractor)	21 Feb 2020	22 Feb 2021
24. Post commissioning monitoring (6 mc	19 Feb 2021	21 Feb 2022