Coetir Mynydd Hydro Scheme
Feasibility Report

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Executive Summary

This report summarises the detailed feasibility work carried out by Dulas Ltd to investigate the potential for a hydro-electric scheme at Felin Fawr reservoir. There is potential for either a 21kW or 15kW scheme, depending on the intake location chosen. The estimated annual generation is 62MWh for the upper intake and 46MWh for the lower intake location.

Based on a full turnkey project delivery, the upper and lower intake capital costs are £303,000 and £228,000 with 'simple payback' periods of 23 and 22 years respectively. The capital figures stated could be significantly reduced by Coetir Mynydd members undertaking elements of the work themselves and using any existing contacts to obtain more competitive pricing.

The current Feed-in Tariff rates are guaranteed for 20 years, but a well designed and maintained hydro system should operate for upwards of 50 years and is therefore generally considered a good long-term investment

In addition to the main report, Dulas have included an additional section discussing the possibility of a smaller, 5kW scheme. This size of scheme would not maximise the potential of the site but would have substantially lower implementation costs.

Statement of Vested Interest
Dulas Ltd are a worldwide-recognised supplier and installer of a range of renewable energy systems and as such have a commercial interest in some of the recommendations contained within the report. In some cases, cost estimates have been given on the basis of current quotations for similar equipment supplied by Dulas Ltd, and may not be the only equipment available. However, it is our opinion that the study offers an appropriate level of detail in view of the resources available and information provided. The authors have no expectation of any order being placed with them and would welcome questioning of the choice and costs of any equipment.

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1 Introduction

This report summarises the detailed feasibility work carried out for a potential hydro scheme on or near Felin Fawr reservoir near Bethesda, Gwynedd. A pre-feasibility study was carried by Dulas in 2010 to investigate the outline potential of two different schemes, one larger scheme with an intake higher up the valley and a smaller scheme located around the reservoir itself.

Coetir Mynydd have chosen to proceed with the smaller scheme and this report builds on the pre-feasibility study and investigates the scheme in more detail. There are two possible intake locations, one at the reservoir dam and a second, higher location, on the first significant bend upstream of the reservoir. The proposed scheme would pipe water from the intake to a new powerhouse built on the site of the existing derelict garage at the foot of Coetir Mynydd's land. Calculations show that, depending on the intake location chosen, either a 21kW or a 15kW scheme are possible and annual generation will be in the region of 62MWh or 46MWh respectively.

The final section of the report, Section 11, discusses a smaller 5kW scheme. Whilst this does not maximise the potential of the site, the scheme should have substantially lower implementation costs and depending on financial circumstances could be an attractive alternative option.

2 Site Survey & Layout Options

A site-survey was carried out by Jonathan Cox and Will Handford of Dulas at the end of July 2011 and a second visit was carried out at the beginning of September. The higher intake location was evaluated and a level survey was carried out to establish the changes in elevation along the length of the scheme. A map showing the proposed scheme locations is included in Appendix A and the various photographs referred to are shown in Appendix B.

2.1 Powerhouse Location

The pre-feasibility work identified the site of an existing derelict garage (Photo 1) to be the most appropriate location for the powerhouse and having completed the detailed study this is still deemed the most suitable location.

There is a high possibility that the existing garage has an asbestos cement corrugated roof. This will need to be investigated further by a suitably qualified surveyor and if asbestos is present, allowance will have to be made for its safe removal.

The location has good access from the road for both the construction of the new building and for future operation and maintenance visits. There is also an existing overhead power line close to the site which, with suitable upgrading as required, can provide the grid connection point.

2.2 Intake Location

There are two possible intake locations, the upper location being at the bend in the river at the upper boundary of Coetir Mynydd's land and the lower location being at the northern end of the Felin Fawr dam.

2.2.1 *Upper Intake Location*

Whilst the upper location (Photo 2) is more difficult to access and there is a difficult pipe route, it is 2.41m higher than the crest of the dam, the height of the lower location. The site is suitable for an intake weir, and it is technically possible to get the pipe out and away downstream of the weir. There are many trees which will make access to the location difficult and will determine the possible pipe route available.

2.2.2 *Lower Intake Location*

The lower location (Photo 3) is much easier to access and minimal tree works will be required to facilitate its construction. The dam is a grade II listed structure so any works will require listed building consent as part of the overall planning application. The weir would be situated at the end of the dam and should not structurally affect the main part of the dam itself.

Whilst the reservoir capacity means that currently it is outside of the requirements of the Reservoirs Act 1975 (reservoirs of water greater than 25,000m^3), it should be noted that changes to the act itself are being considered which would reduce the reservoir qualification to capacity to just 10,000m^3. Given that the surface area of Felin Fawr is 5,100m^2, there is a good chance that it would qualify under the proposed changes.

2.3 Available Gross Head

The gross head (height difference), between the lower intake location and the powerhouse floor level was surveyed as 9.27m. The upper location is 2.41 m higher than this, giving an overall gross head for the upper intake as 11.68m. The powerhouse floor level is 2.1m above the outfall point, located just upstream of the lowest dam.

2.4 Proposed Pipe Route

The proposed pipeline routes are shown on the map in Appendix A.

2.4.1 *Upper intake to reservoir*

The first section of pipe from the intake would be buried through the trees until it reached the point where the river bed comes right to the path (Photo 4). From here to the dam, the pipe would be laid on the surface just above the average mean flow level. As the pipe will be submerged at times of high flow and as the proposal is to use polyethylene pipe, regular anchor blocks will be required for this section to stop the pipe from 'floating' when partially submerged.

2.4.2 *Reservoir to powerhouse*

For both options the pipe will run from the corner of the dam down to the slight path / ledge approximately 2m below (Photo 5). The pipe would then run along the surface of this ledge as far as possible and then in a straight line through the trees to the powerhouse. Surface laying was recommended by the Environment Agency officer during the pre-feasibility work to minimise tree root damage and associated installation costs will be reduced. However, the client should give consideration to the possibility of vandalism if the pipeline was arranged in this manner.

2.5 Outfall

Having passed through the turbine, the water would be returned to the river, via a suitably screened pipe, just above the lowest dam (Photo 6).

2.6 Construction Access

It is anticipated that plant and materials for the intakes and upper sections of pipe route would need to access the site via the fields to the north of Coetir Mynydd's land. A section(s) of the field wall would need to be dismantled for the construction phase and re-built afterwards. This will require agreement of the landowner, and if amenable, alongside the wall would also make an ideal site for a small storage compound and pipe lay-off area.

For the rest of the pipeline, the pipe would be formed from the individual sections at the dam and winched along the route to the powerhouse.

The powerhouse and outfall sections of the project can be easily reached from the existing access track and there is also sufficient land surrounding the powerhouse to create a temporary construction compound to house a site office / welfare facilities and additional materials.

2.7 Land ownership

Both schemes are located entirely on land owned by Coetir Mynydd and therefore no land ownership issues are anticipated with the project once construction is complete.

As discussed above, the construction phase would ideally have access to the intake locations and pipe route via the fields to the north of the site. It is assumed that agreement can be reached with the land owner as, whilst not impossible, access would be significantly easier and hence cheaper if this was a possibility.

3 Hydrology & Abstraction

3.1 Hydrology

In order to estimate the potential for hydro power it is necessary to estimate the flows in the river. The catchment area has been defined and a LowFlows[1] simulation has been run to give an estimate of the flows at different times of year. The data is presented in the form of a flow duration curve and is based on historical rainfall data and similar catchment areas to give a long-term statistical average. The simulation input data was adjusted to include the compensation flows (a minimum of 17l/s) discharged from Marchlyn Mawr reservoir. The results can be seen in Figure 1 below.

In 2006, Bryn Williams carried out regular flow measurements at the dam. Whilst this data only shows the river's flows for one particular year it is useful for comparing with the LowFlows estimate to give some confidence to the simulation results. Bryn's data is also shown in Figure 1 and it can be seen that the curves are very similar, with slightly lesser high flows and slightly greater low flows measured than the long term average.

[1] LowFlows developed by the Centre for Ecology and Hydrology and available from Wallingford HydroSolutions Ltd at www.hydrosolutions.co.uk

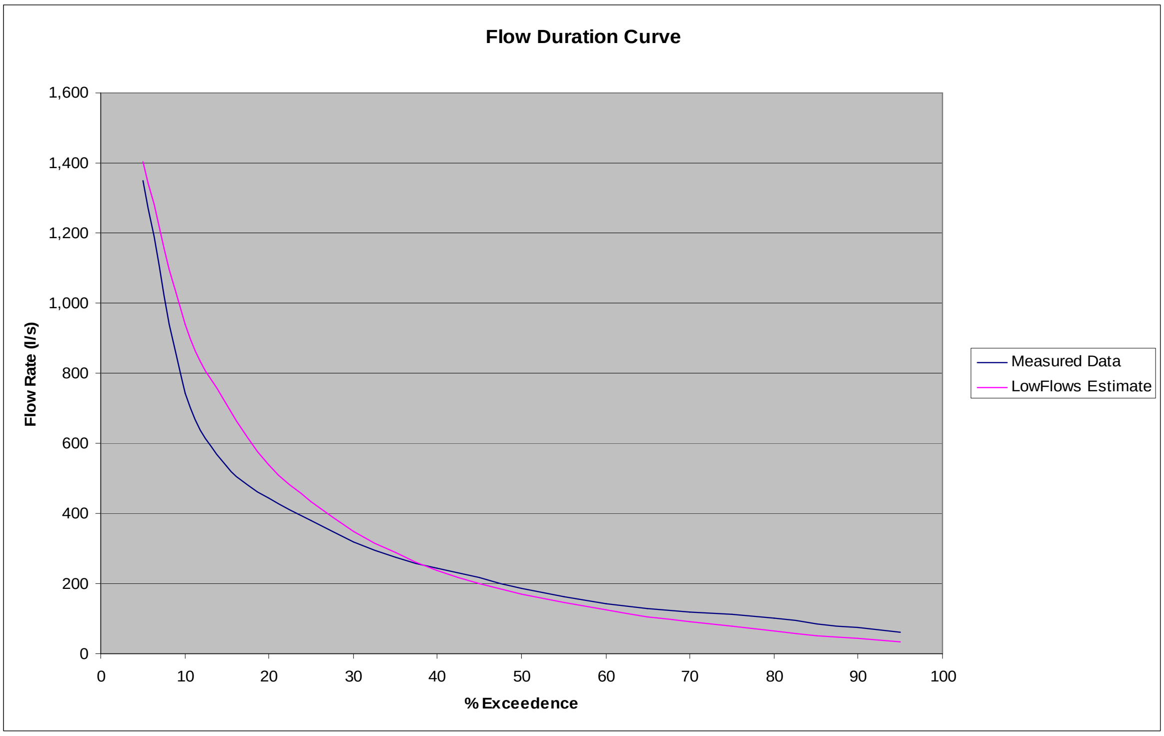


Figure 1. Flow Duration Curve

3.2 Abstraction Allowance

Since Dulas' pre-feasibility study, Coetir Mynydd have contacted the Environment Agency (EA) and been through the pre-application process. As a result of this, the EA have specified the abstraction allowances that are likely to be granted as part of the abstraction licence. The EA base their recommendations on their own hydrology team' flow estimations which have been compared with and are in line with Dulas' LowFlow results.

The key points are that a compensation, "hands-off" flow of Q95 (36l/s) must remain in the river at all times and the maximum abstraction from the river (at any time of the year) is the flow equivalent to the average annual daily flow, in this case 374l/s.

For river flows above the compensation flow, 50% of the flow above 36l/s may be abstracted from April to November. From December to March, the allowable abstraction figure is increased to 70% of any flows above 36l/s. The intake must be screened with a Coanda screen with wire spacing not exceeding 3mm and the outfall must have a screen with a maximum spacing of 10mm.

3.3 Intake Design

Coanda screens are the ideal solution for small hydro intakes, being effectively self cleaning and requiring no power supply. They exclude small particles as well as smolts and vegetation and they are approved by, and as can be seen above, often specified by the EA.

3.3.1 Upper Intake Option

In order not to exceed the abstraction percentage permitted, the intake structure is designed such that ratio of the screen width to the total weir width is the same as the ration of the abstraction allowance to the total flow. This physical separation ensures the residual flow is maintained at all times. It is however necessary to alter this ratio to allow for the increase abstraction allowance during the winter months. This can be achieved by inserting a timber ‘stop-log’ into the weir at the beginning of December and removing it at the end of March.

The existing left bank height (looking downstream) means that a low relief weir is needed to prevent flooding upstream. This requires the use of reduced height Coanda screens (1/4 of full height) and hence the length of screen needs to be increased to accommodate the maximum abstraction rate. The overall structure will be approximately 3m longer than the existing river width and so some bank removal and bed scour protection work will be required and a raised section of bank will need to be created to contain any potential flood flows.

The Q95 ‘hands off flow’ is maintained by an orifice plate in the weir that is situated lower than the weir crest and hence ensures this flow is maintained at all times. This arrangement is normally acceptable to the EA in Dulas’ experience. A 3D model of the proposed structure is shown in Figure 2 below.

Figure 2. Upper intake outline design

3.3.2 *Lower Intake Option*

In a similar way to the upper intake option, there needs to be a physical structure to partition the flows to ensure the abstraction allowance is not exceeded. The structure has been designed such that the residual and “hands-off” flows discharge over the dam as usual and only the allowable percentage of flows pass over the intake screen. Any flows exceeding the maximum abstraction allowance will flow over the screen and down the new spillway to the toe of the dam.

The structure has been designed to involve minimal alteration to the dam itself whilst maintaining the required dimensions to ensure it works hydraulically. The crest height of the dam will need to be fractionally raised to ensure the flow partioning is maintained in the correct proportions. A model of the structure is shown in Figure 3 below.

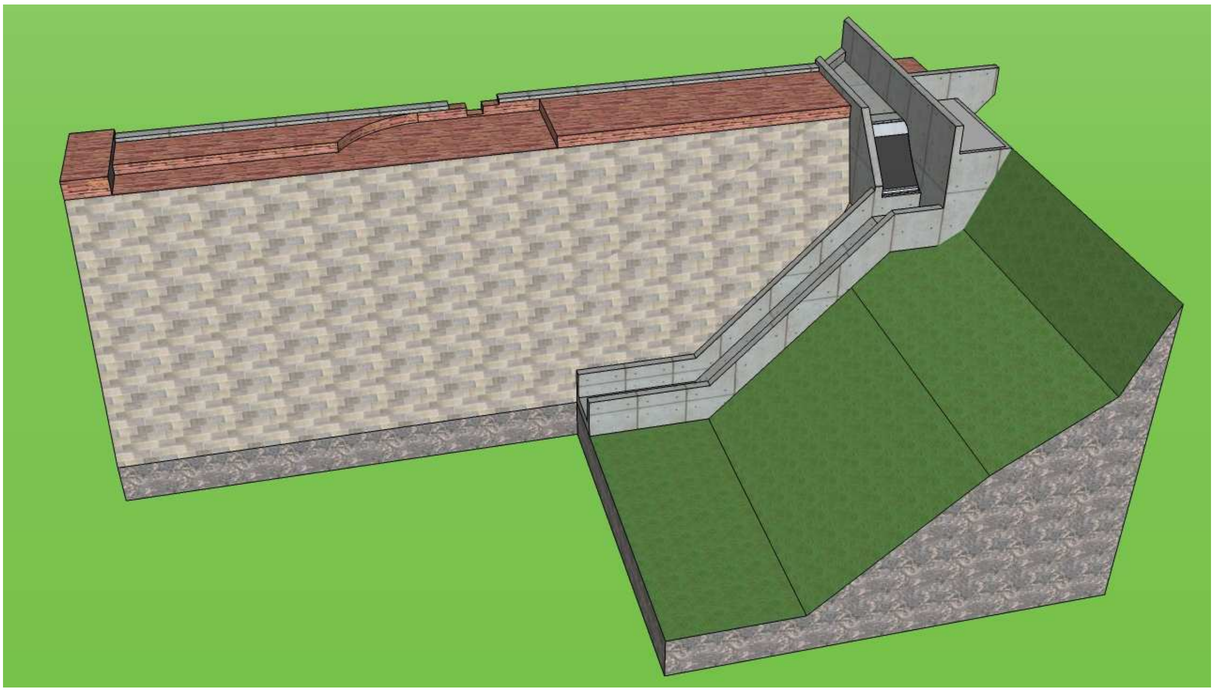


Figure 3. Lower intake outline design

3.3.3 Flood Defence Consent and Flood Consequence Assessments

Flood defence consent is generally not applied for until the detailed design phase is complete as exact structure dimensions and construction methodologies are required for the application process. It can be applied for separately to the abstraction and impoundment licences and as such will not delay the permitting process.

Once the intake location is finalised, a preliminary discussion with the EA's Development and Flood Risk Engineer should be carried out to ensure all the required information is covered in the detailed design phase and to identify the scale and nature of any Flood Consequences Assessment.

4 Planning & Archaeology

An outline of the proposals was sent to the local planning officer (Glyn Llewelyn Gruffudd) at Gwynedd County Council for comment. Following this a detail discussion was had with the planning officer and he will forward his formal response at a later date, this will be forwarded to Coetir Mynydd as soon as it is received. The key points are listed below:

- Generally positive about the proposal, especially as it is for a community scheme
- The dam is listed but if alterations to it ensure its ongoing survival then that will be a positive consideration
- There are no other listed structures within the project boundary
- Surface mounting the pipe is agreeable as it minimises root damage
- There are no tree protection orders within the project boundary
- A tree survey is likely be required, especially if the upper intake is chosen
- The council's Biodiversity Officer and Highways Department should also be contacted prior to a formal application being submitted
- A new powerhouse building replacing the derelict garage would favourable if it improved the general state of the area

- A textured pre-fabricated building could be acceptable though a traditional stone clad, slate roofed building will always be preferable
- There are no anticipated problems with upgrading the overhead power line

A search of the CADW and CCW data sets have highlighted no other significant issues.

5 Equipment Options

The following sections outline the most suitable equipment for the scheme.

5.1 Turbine

The gross head and available flow determine the most appropriate turbine choice for any particular site. For this site, a propeller or cross-flow turbine is most appropriate.

A small propeller turbine would suit this site well as the full outfall head could be exploited. This would increase the gross head by perhaps 2m, an increase in 18%, which would be reflected in energy generation. However, the efficiency of a propeller turbine drops considerably in 'part design flow' operation. A 'semi-kaplan' turbine would address this issue.

Unfortunately propeller and semi-kaplan turbines of the (small) size required for this site are not readily available commercially and those that are, are disproportionally expensive due to their limited demand. However, cross-flow turbines are more readily available commercially and at this size operate efficiently at 'part design flow' conditions and hence a cross-flow turbine is proposed.

The calculations and costings included in this report are based on electro-mechanical plant and control system supplied by Cink Hydro Energy in the Czech Republic. A copy of their quotation is included in Appendix E and a picture of a similar machine to that proposed is shown in Figure 4 below.

Cink have been chosen due to their quality of manufacture, reputation, installation history and our confidence in their continued back-up and support once installation is complete, giving peace-of mind for ongoing trouble free operation. There are other suppliers available including those such as Ecowave, Evans Engineering and the Indonesian company Heksa. A significant reduction in price could be available though it is vital to ensure quality standards are kept high and that manufacturer's stated efficiency values and guarantee / warranty terms can be upheld.

Delivery times are typically around 6 months, meaning that orders should be placed early on in the project construction program.

Figure 4. Cink cross-flow turbine (no gearbox or generator shown)

Cink's proposal is for a double cell crossflow turbine. This optimises efficiency of the turbine across all operational turbine discharges. It does require a second actuator and the fabrication of two cells within the turbine. For a unit of this size and expected operation, a cheaper, single cell crossflow turbine would produce only marginally less power (and annual generation) than the two cell machine and should be appreciably cheaper to supply.

5.2 Gearbox and generator

For this site a gearbox (1:2.5 speed ratio) will be required to increase the turbine rotational speed to match the generator. This will be fitted with a suitable temperature sensor to ensure an alarm is triggered before any damage is done due to overheating. However, during the detailed design / implementation stage of this development, it will be worth reviewing with Cink on whether a smaller diameter crossflow turbine runner could be used running at a fast enough speed to drive a 750rpm induction generator directly. This would simplify the electro-mechanical package and reduce the capital cost whilst at the same time increasing the width of the turbine. Given the low head that the turbine operates at, the increased width should be feasible to fabricate without impacting on the durability of the runner.

The generator will be an asynchronous generator fitted with an anti-condensation heater and both winding and bearing temperature sensors to again trigger an alarm if any item begins to overheat.

5.3 Control System

The control system will included automatic response to fault conditions, a UPS power supply to allow controlled shut-down in the event of mains failure, GSM modem for remote monitoring and control and a river level sensor to ensure abstraction licence requirements are met. In addition the power section of the control system will contain all the suitable protective relays / switchgear to ensure G59/2 regulations are met as required Scottish Power Energy Networks (SPEN), the local Distribution Network Operator (DNO).

5.4 Flow meter

The EA now no longer require flow meters to be installed on small hydro schemes, as they are happy to derive data from the electricity generation meter readings. Some calculation / calibration is required to correlate electricity output with flow.

On the other hand, flow meters are useful for commissioning and monitoring purposes. They cost in the region of £1-2k (for an ultrasonic meter) and are usually installed in a separate chamber outside the powerhouse as they require a straight section of pipe before and after the sensors.

5.5 Pipeline

The proposed pipe material is High Performance Polyethylene (HPPE) plastic[2]. The material is robust, and pipe sections (typically 12m long) can be butt-welded to form a continuous length, reducing the need for anchor blocks and also reducing the risk of joint failure.

5.5.1 Pipe Wall Thickness

The gross head of just less than 12m suggests that hydraulically, a pipe rated at PN6 (SDR33) would be more than adequate to withstand the operating and potential surge pressures that may be encountered. As the pipe is to be surface mounted, there is a risk of mechanical damage from falling debris (tree branches etc) or vandalism. Specialist advice was sought from a supplier of HPPE pipe work as to what thickness pipe wall should be implemented to minimise the likeliness of mechanical damage and PN8 (SDR21) is proposed as recommended.

5.5.2 Pipe Diameter

The pipe diameter is determined by a number of factors including the hydraulic losses and cost of the materials and installation. Pipe diameters of 350mm up to 600mm were investigated and taking all the various factors into account a 500mm pipe diameter is considered to be the optimum size.

5.5.3 Pipe Installation

For the section of pipe from the dam to the powerhouse, the pipe will be secured to buried concrete plinths placed strategically to restrain excess movement of the pipe whilst avoiding tree root damage as much as possible. If the upper intake was chosen, this section of pipe will need to be secured at much more frequent intervals (every 3.5 - 4m) to locate the pipeline during periods of high or flood flows.

5.6 Powerhouse

The proposed powerhouse is single story with a footprint of 4m x 6m. The main element of the construction will be the floor slab, which will need to incorporate thrust blocks to take the forces applied to the pipe and turbine, a plinth for the generator, and the sump under the turbine leading to the outfall pipe.

With regard to the actual structure of the powerhouse, a pre-fabricated building can bring considerable cost savings over a more traditional block-work construction building, stone clad with a slate roof. Modern textured pre-fabricated finishes enable

[2] Polyethylene (PE) is usually referred to as High Density (HDPE) or Medium Density (MDPE). The material used in the manufacturing process of HDPE and MDPE pipe and fittings is generally PE80. High Performance Polyethylene (HPPE) is a high density polyethylene, manufactured from a PE100 material which provides a greater strength than PE80 with an equivalent wall thickness.

a realistic looking building to be created at approximately half the price. An example of a similar pre-fabricated building is shown in the Figure 5. The powerhouse will need ventilation (usually fan-assisted), but due to the distance from the nearest dwelling, it is unlikely to require a high level of sound proofing. A plan view and section of the proposed powerhouse is shown in Appendix C.

Figure 5. Pre-fabricated, stone effect building

5.7 Outfall

After passing through the turbine, the water will be returned to the river via a low pressure buried pipe (e.g. 500mm twin-wall) or along an open channel. The length will be approximately 15m with a drop from powerhouse floor to river level of around 2m to prevent back-flooding.

6 Power, Energy Output and Gross Income

6.1 Generated Energy Sales Prices

All of the power generated will be exported to the grid, and a power purchase agreement (PPA) will be needed with an energy supplier. The UK energy market for renewable energy changed over to a Feed in Tariff system (FiT) in April 2010 and this system supersedes the Renewables Obligation (RO) system for schemes of this size.

The total price is made up from an export tariff and a generation tariff. The base energy export market currently has a floor price of £31/MWh, but this can be opted out of if a better price can be found from a supplier who will buy the energy. Market forecasts suggest that £40/MWh will be comfortably achievable via a suitable PPA.

The generation tariff is an additional payment for every MWh generated, regardless of whether it is exported or used on site, and this forms the bulk of the income. Both elements are index linked and the table below summarises the situation for hydro schemes of various sizes.

Scheme Capacity (kW)	Generation Tariff (£/MW)	Fixed Export Tariff (can opt out) (£/MW)	Total Tariff Value (£/MW)
0 to 15	209	31	240
15 to 100	187	31	208

6.2 Energy Output Calculations

The following estimations are based on a Cink cross-flow turbine, using manufacturer's efficiencies and expected performance. Firstly the head and design flow are used to give the maximum power output of the scheme (kW). The energy output (MWh) is then calculated over the year, taking into account the variations in available flow.

The calculations make the following assumptions:

- Upper and lower schemes are based on 11.68 and 9.27m gross heads respectively.
- Lowflows hydrology, with an ADF of 374 l/s which is the maximum that can be abstracted.
- Fixed residual or 'hands-off' flow of Q95 (36l/s).
- Abstraction allowance of up to 50% of the available flow above Q95 from April to November and 70% for the remainder of the year.
- Minimum flow of 15% of maximum turbine flow.
- 2% downtime
- Export price of £31/MWh

Results are as follows, with a summary sheet and example month's calculations shown in Appendix D.

Option	Maximum Turbine Flow Rate (l/s)	Max Power (kW)	Energy (MWh/yr)	FIT Price (£/MWh)	Gross Average Annual Income under FITS
Upper Intake	360	21	61.85	187 + 31	£13,483
Lower Intake	290	15	45.98	209 + 31	£11,036

[Energy outputs (and therefore income) are average estimates based on statistically derived data and can vary significantly (typically ±20%) depending upon total rainfall and the distribution/intensity throughout the year.]

7 Grid Connection

Scottish Power Energy Networks is the DNO for the North Wales region. Discussions with SPEN have suggested a connection would not be a problem at this scale but for a definitive answer a formal request will have to be submitted.

The calculations in this study have been based on having a 3-phase connection to the distribution grid. The overhead line that spans the area close to the powerhouse is only single phase and would need to be upgraded to 3-phases to enable the options chosen to be implemented.

There is a 11kV/400V pole mounted substation located approximately 50m from the powerhouse site (see SPEN map in Appendix A and Photo 7). It would be possible to upgrade the existing single phase overhead line to a 3–phase line from this substation to the powerhouse where a new telegraph pole would be required to make the terminations. The cost for this work has been included in the overall capital costs of the schemes.

An alternative option is to use a single phase generator although the efficiency is likely to be less and hence there will be less annual generation and hence less income. This option would still require a new telegraph pole close to the powerhouse to make the required terminations but no upgrade to the overhead line would be required.

8 Financial

8.1 Budget implementation costing

A budget cost for each scheme is provided in Appendix E. These give estimated construction costs of £303,000 for the upper scheme and £228,000 for the lower scheme.

These costs are for a turnkey installation using standard Dulas rates and our usual contractors and suppliers. The final pricing structure would depend on allocation of risk, the type of contract used (fixed price turnkey, target price or time & materials), contingency and if any elements of the project can be carried out at reduced cost through Coetir Mynydd's connections / involvement. It should be noted that no allowance has been made for management time or costs incurred by Coetir Mynydd.

Costs for the lower intake scheme were estimated as part of Dulas' pre-feasibility report at less than half of the estimated costs shown in Appendix E. An explanation for the difference in costs has also been included in Appendix E for information.

8.2 Operational costs

Operational costs will include:

- regular maintenance visits (greasing bearings, brushing screens, etc)
- annual inspection visits (full system checks)
- minor repairs
- business rates and taxes
- electricity use of system charges, import electricity and metering
- insurance

Maintenance fees can be significantly reduced if a competent local person can be employed as caretaker. An annual visit from an experienced hydro engineer should also be allowed for, and a provision should be made for more serious repairs every 3-5 years or so, although a good and diligent maintenance regime will reduce the risk of such problems.

Use of electrical rather than hydraulic vanes can also reduce the maintenance costs, which can be £500 per year for professional servicing, though the initial capital costs will be higher.

Local rates will need to be investigated as they vary considerably between regions, and a rating should be obtained from the Valuation Office Agency (VOA).

Taxes and loan payments again depend on individual circumstances and have not been included below.

Insurance can cover only the plant and machinery, or also include lost generation due to faults – however the premiums can be quite high for this, and is usually only worthwhile for larger schemes. Adding cover to an existing business or estate policy is often the cheapest way to insure a scheme, and the cost will depend very much on local circumstances. For budgeting purposes, a figure of 20% of the annual income, in this case, £2-£3,000 should be allowed for.

8.3 Net Income

With an estimated gross annual income for the upper and lower schemes as £13,483 and £11,036 respectively under the Feed-in Tariff, the "simple payback" for each scheme is in the region of 22 years for the upper scheme and 21 years for the lower scheme.

8.4 Lifetime

Hydro schemes generally have a design life of 40-50 years, but with a major overhaul after 15-20. This is not a replacement of the whole plant, but could for example be replacement of the turbine runner in cases where there is significant sand or silt in the water which would cause wear.

The generator will maybe last 15 or 20 years, but again this will depend on circumstances – a generator in a warm, dry powerhouse with stable grid will last longer than one that sits off-line in a damp powerhouse, or where there are frequent grid faults. Bearings (turbine and generator) typically need replacing every 100,000 running hours (about 8-12 year intervals).

Valves are the other main mechanical components and these should need little maintenance. Electrical components will need replacing periodically (e.g. the main contactor) and there are consumables such as fuses, relays and lightning protection.

It should be noted that the cost of engineering time (and travel time in this case) is generally much more than the cost of replacement parts, as is the loss of generation during enforced shutdowns. Holding stock of critical spares and having a good operation and maintenance regime are therefore vital.

Generally, hydro is seen as a good long-term investment, as long as the plant is well designed and built to begin with and looked after by competent people. Dulas have recently refurbished a scheme in North Wales where the two Turgo turbines ran for just under 100 years.

9 Implementation

9.1 Project program

Hydro schemes are usually built in several stages as follows:

<u>Development phase</u>

- Feasibility study and outline design
- Obtaining consents (planning, abstraction, grid connection agreement)
- Funding arrangements and plan for managing the implementation

<u>Implementation phase</u>

- Detailed design
- Issue of tender(s) and ordering of equipment

- Civil construction
- Installation of electro-mechanical plant and commissioning
- Handover and warranty period (typically 12 months)

There is usually some iteration during the consents stage as the outline design is finalised. The consents phase typically takes 6 months (or more), with 3 months for detailed design and an actual construction period of 6–9 months, depending on supplier delivery times and seasonal construction issues.

Commissioning and de-snag with take a further 1–2 months. For turn-key installations some of the design work may run concurrently with the construction.

9.2 Management and Contracts

If the scheme is to be a "turn-key" then a principal contractor will be appointed to manage the whole project. Different sub contractors may then be used for the intake construction, pipeline installation, power house build and electro-mechanical installation and commissioning. In all cases, a clear management and responsibility structure is key to implementing a successful scheme.

Standard Engineering, Procurement & Construction (EPC) contracts, such as those produced by NEC[3], are suitable for implementing micro-hydro developments and any associated sub-contracts for civil works and major supply items.

It should be noted that any turn-key or fixed price contract will include an element of contingency (as the risk is placed with the main contractor) and will therefore not necessarily be the cheapest option. "Target Contracts" are becoming increasingly popular as a way of sharing risks and rewards, with the contractor and client forming a partnership to keep the overall budget down. However this requires high quality project management on behalf of both contractor and client and may be more trouble than its worth for the sort of contract environment envisaged with this development.

9.3 Health & Safety

Building such a scheme will fall under the Construction (Design and Management) Regulations (CDM)[4] which were revised in 2007. This places a legal obligation *on the client* to appoint a "CDM Co-ordinator" to oversee the project from a Health and Safety point of view. This service can be supplied by independent consultant or civils companies for about £1,500 and has been included in the capital cost estimates.

Early appointment before during detailed design can help to avoid potential problems before construction starts, and can result in a better all round scheme.

[3] http://www.neccontract.com
[4] www.hse.gov.uk/construction/cdm.htm

10 Recommendations

If the scheme is to progress, the following actions are recommended:

- Decide on the preferred intake option
- Review electro-mechanical supply options. If it is decided to pursue a commercial supply from Cink, they should be asked to check carefully whether the gearbox is really needed (a faster, smaller diameter runner might be suitable for direct connection to an induction generator running at say 750rpm). Similarly, the need for cell partitioning should be examined. The loss of a partition should reduce costs with small impact on generation.
- Investigate the possibility of a single phase generator and having finalised the connection, commission a grid connection study, either through the DNO or an independent supplier to establish actual grid connection costs
- Commission a tree survey, particularly if the upper intake option is chosen and any other environmental surveys required by the council biodiversity officers.
- Submit formal planning and abstraction licence applications
- Arrange agreement (ideally legal) with neighbouring landowner regarding construction access across the northern fields
- Investigate and finalise funding arrangements
- Commission detailed design and issue tenders for construction

11 A 5kW Scheme

The two schemes discussed in the report above maximise the generation, and hence income available, at the site. An alternative scheme would have a limited power output but due to the smaller size of the scheme should have substantially lower implementation costs. Costs savings should be possible in the following areas:

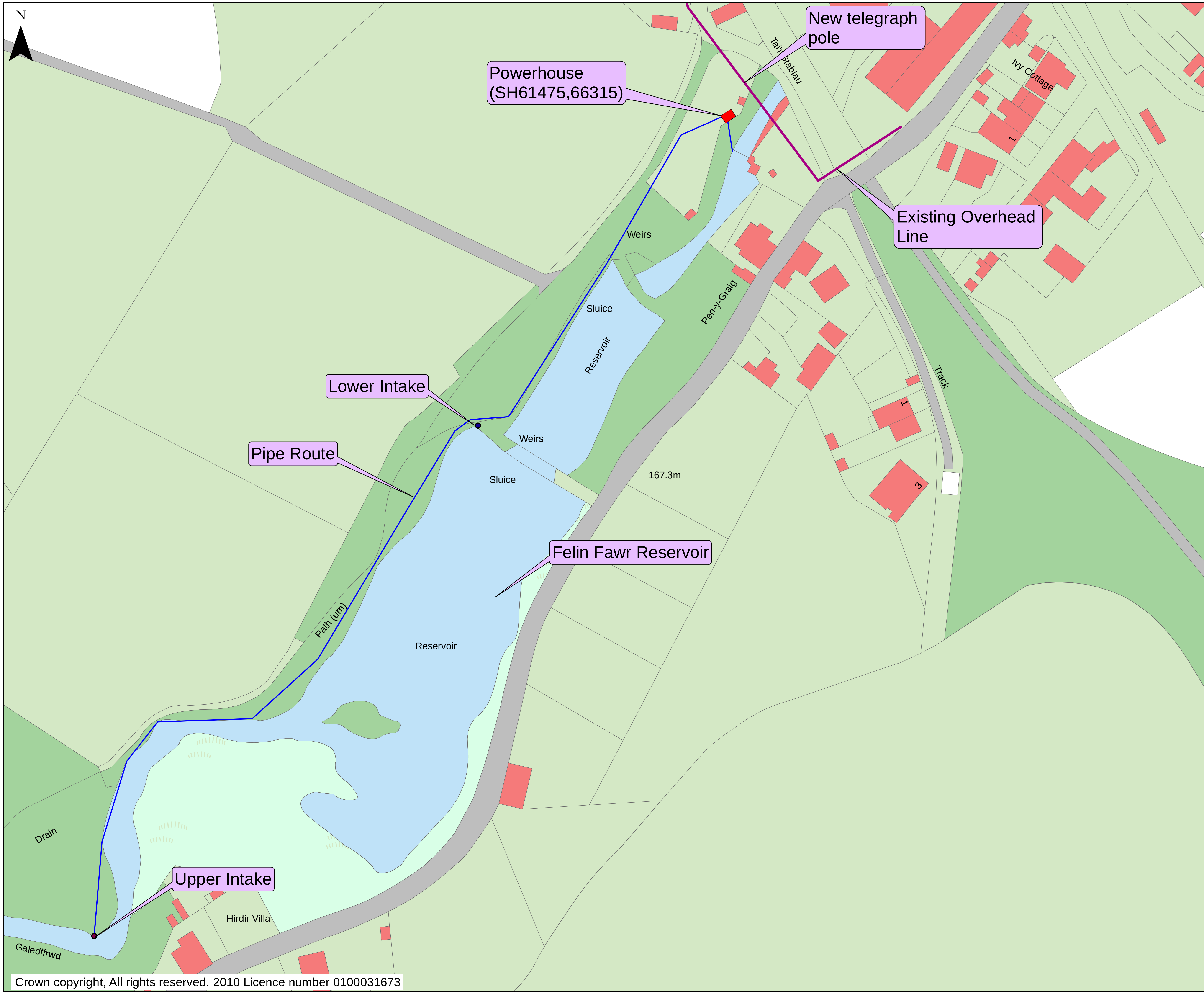
- Intake screens – a smaller screen can be used due to less water being abstracted and this also reduces the head loss due to the screen by 500mm
- Pipe – due to the lower abstraction rate, a smaller diameter pipe can be used whilst maintaining acceptable losses. This will lead to cheaper pipe sections as well as smaller anchor blocks and valves
- Turbine – a smaller and simpler turbine can be used as less power output is required and hence less substantial foundations are required
- Generator - a single phase generator can be used, which would not require the existing overhead cable to be upgraded though a new telegraph pole would still be required to actually make the connection
- Control Panel – due to the lower power output, smaller components and switchgear can be used
- Powerhouse – due to the smaller equipment, a less substantial powerhouse could be constructed

There are several small companies that specialise in installing schemes of this size and again a cost saving is possible as typically these companies will have lower overheads than a larger consultancy such as Dulas.

The exact power output will depend on the equipment chosen, but as an illustration, power and energy output calculations for a 5kW scheme are shown in Appendix F. These show that a 5kW scheme would generate an estimated 26.5MWh per year equating to an income of £6,350 under the current feed-in tariff rates.

Under the current feed-in tariff rules, the tariff cannot be claimed if grant funding was used to finance the capital costs of the scheme. It is however still possible to enter into a power purchase agreement to sell the energy generated and current estimates suggest a rate of 4-5p/kWh should be achievable. This means that if grant funding was secured, an annual income of just £1,000 should be possible.

Appendix A – General Layout & SPEN Maps



Notes

For Consultation Only

0 10 20 40 Meters

REV	DATE	NAME	DESCRIPTION
A	23.09.11	WH	For consultation only

www.dulas.org.uk

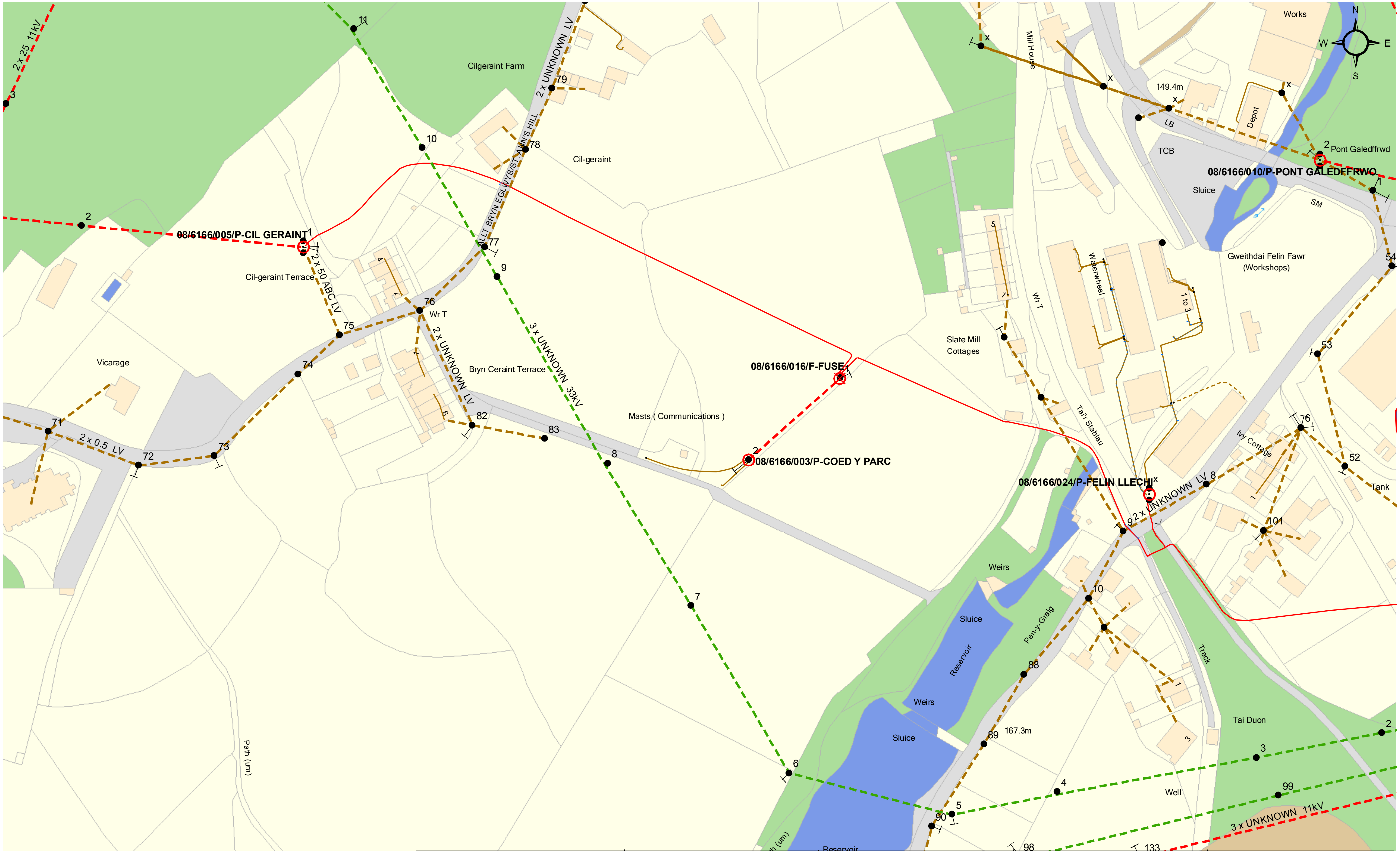
CLIENT
Coetir Mynydd

SITE NAME / LOCATION
Mynydd Llandegai

PROJECT No.	SCALE (at A3)
HF02769	1:1,000

DRAWING TITLE
General Layout

DRAWING No.	REVISION
HF02769-MAP01	A



The position and depths of underground and overhead apparatus as indicated on this plan are approximate and are intended for guidance only. The depths may have changed if the land surface levels have altered. You are also informed that the plan may not show, or may inaccurately show, individual property services and services to street lighting installations. The onus of locating the apparatus precisely before commencing any excavations or other works in the immediate vicinity therefore rests entirely upon the person undertaking or responsible for those works. Before any such works are undertaken the precise location of the apparatus and cables should therefore be ascertained by suitable means. In the event of an emergency or for further assistance please contact 0845 272 7979 (ScottishPower area) or 0845 272 2424 (SP Manweb area).

SP ENERGY NETWORKS
On behalf of SP Manweb plc

SP Manweb plc
Registered Office: c/o PowerSystems
3 Prenton Way, Prenton, CH43 3ET
Registered in England and Wales No 2366937

OVERHEAD LINE

UNDERGROUND CABLES

In Use
Out of Use
Assumed route

VOLTAGE COLOUR KEY

EHV	132kV	BLUE
	33kV	GREEN
HV		RED
LV		BROWN

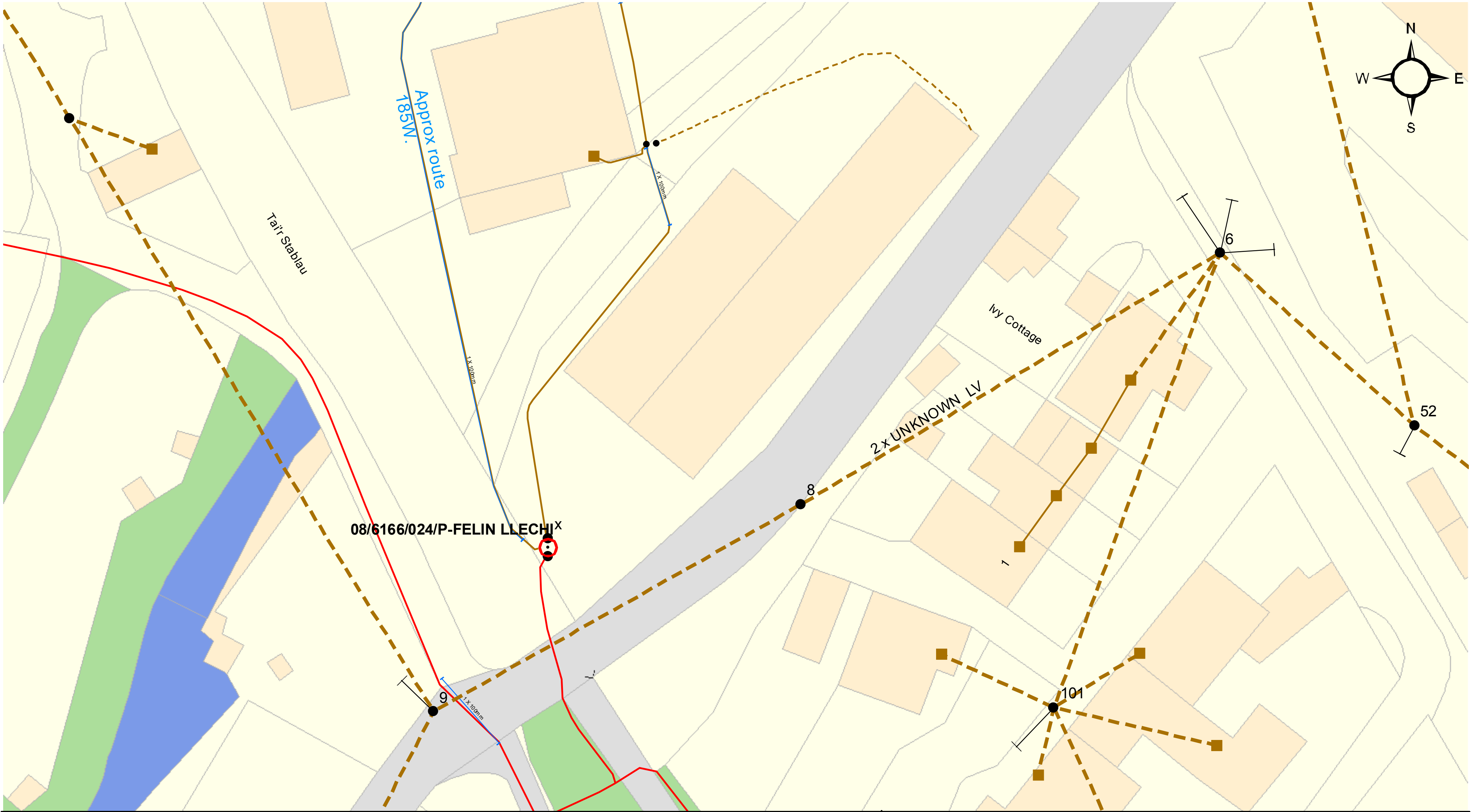
Where cables have been laid SINCE 1 OCTOBER 1988, the following depths in mm apply (to the tops of cables or ducts) UNLESS OTHERWISE SHOWN, but see comments.
(TO TOP OF CABLE, ADD 75mm FOR BOTTOM OF TRENCH)

	EHV	HV	LV
IN FOOTPATHS :	775	600	450
ACROSS ROADS :	775	700	600
ALONG ROADS :	775	700	600
AGRICULTURAL :	910	910	910

Your attention is drawn to the Health and Safety Executive Booklet HSG47, available from HSE.

DATE	23/09/2011
SCALE	1:1466
MAP REFERENCE	261323 366295

0 5 10 20 30 40
Metres



SP ENERGY NETWORKS
On behalf of SP Manweb plc

SP Manweb plc
Registered Office: c/o PowerSystems
3 Prenton Way, Prenton, CH43 3ET
Registered in England and Wales No 2366937

OVERHEAD LINE

UNDERGROUND CABLES

In Use

Out of Use

Assumed route

VOLTAGE COLOUR KEY

EHV	132kV	BLUE
	33kV	GREEN
HV		RED
LV		BROWN

Where cables have been laid SINCE 1 OCTOBER 1988, the following depths in mm apply (to the tops of cables or ducts) UNLESS OTHERWISE SHOWN, but see comments.
(TO TOP OF CABLE, ADD 75mm FOR BOTTOM OF TRENCH)

	EHV	HV	LV
IN FOOTPATHS :	775	600	450
ACROSS ROADS :	775	700	600
ALONG ROADS :	775	700	600
AGRICULTURAL :	910	910	910

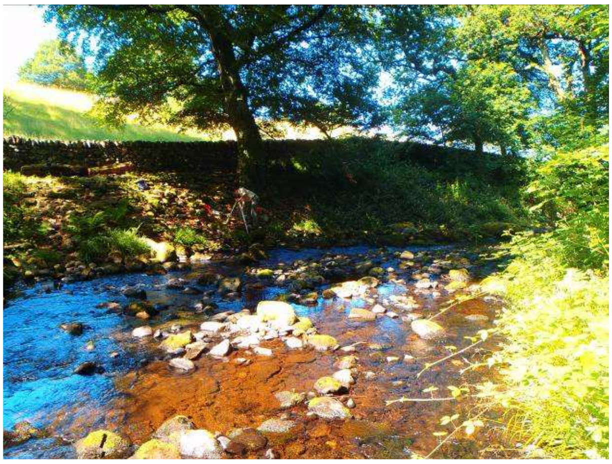
Your attention is drawn to the Health and Safety Executive Booklet HSG47, available from HSE.

DATE	31/08/2011
SCALE	1:500
MAP REFERENCE	261529 366295

0 2 4 8 12 16
Metres

Appendix B – Photographs

#	Photograph	Description
1.		Derelict garage on site of proposed powerhouse location
2.		Upper intake location
3.		Lower intake location

4. 

Pipe to be laid along river edge on LHS of photo

5. 

Pipe to be laid along surface through the trees

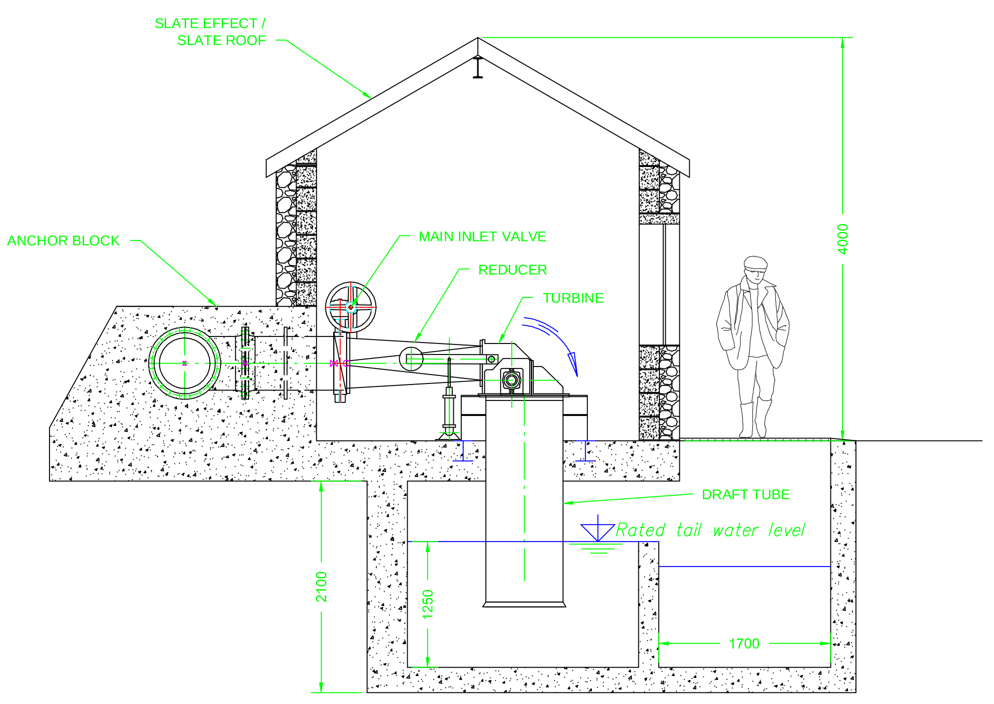
6. 

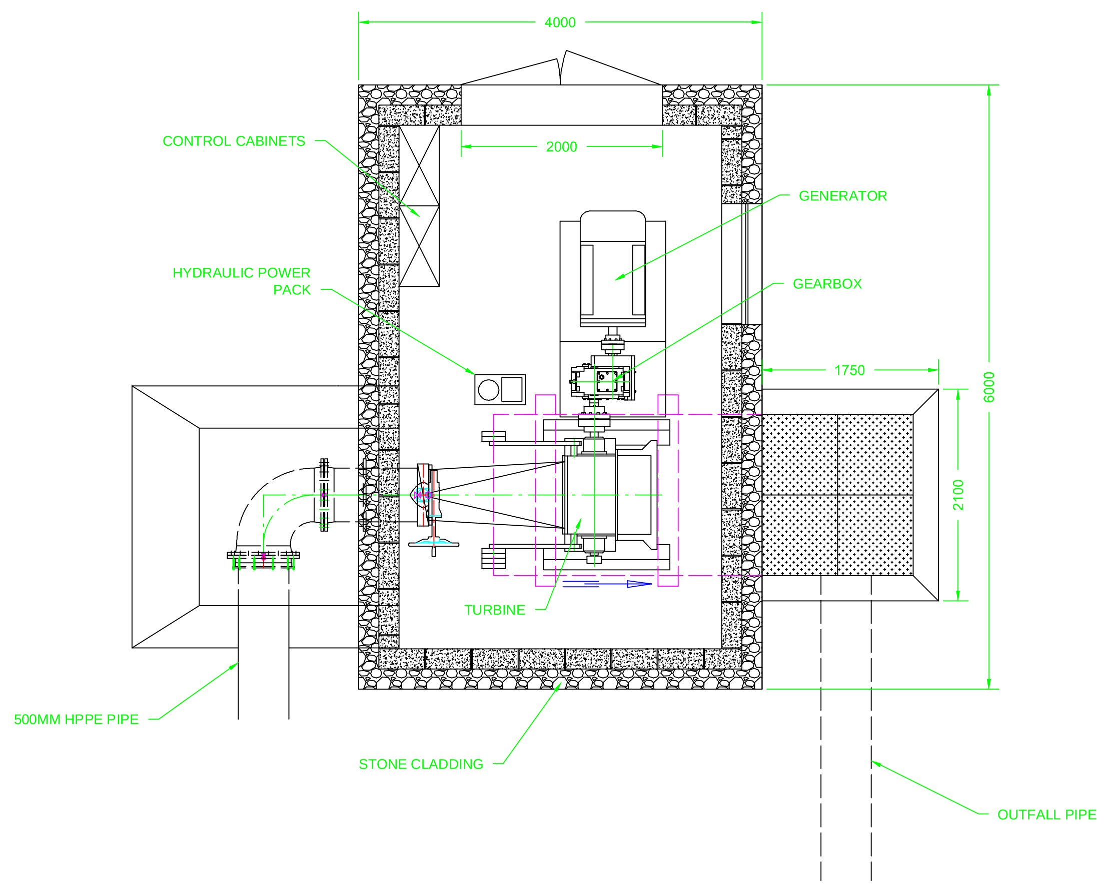
Outfall to discharge above dam shown

7.

Existing 11kV sub-station

Appendix C – Powerhouse Drawings





FOR FEASIBILITY STUDY ONLY

Notes

REV	DATE	NAME	CHKD	DESCRIPTION
A	07.10.11	WH	JVC	FIRST ISSUE

DULAS LTD, UNIT 1 DYFI ECO PARK, MACHYNLLETH
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TEL: +44(0)1654 705000 FAX: +44(0)1654 703000
www.dulas.org.uk

CLIENT: COETIR MYNYDD
PROJECT: FELIN FAWR HYDRO SCHEME
LOCATION: MYNYDD LLANDEGAI
PROJECT No.: HF02769
SCALE: 1:10 at A3
DRAWING TITLE: POWERHOUSE LAYOUT
DRAWING No.: HF02769-DWC-01
SHEET: 1 of 1
REVISION: A

Appendix D – Power & Energy Calculations

Comparison of monthly generation and income

	Upper Intake			Lower Intake		
	Energy (MWh)		Income	Energy (MWh)		Income
Annual	**60.44**	**£**	**13,176**	**45.49**	**£**	**10,918**
Jan	9.20	£	2,005	6.68	£	1,603
Feb	6.62	£	1,443	4.84	£	1,162
Mar	6.88	£	1,499	5.08	£	1,218
Apr	3.45	£	753	2.71	£	650
May	2.58	£	563	1.99	£	479
Jun	1.96	£	426	1.57	£	377
Jul	1.80	£	393	1.47	£	354
Aug	3.13	£	682	2.38	£	572
Sep	4.10	£	894	3.07	£	736
Oct	6.24	£	1,360	4.62	£	1,108
Nov	7.17	£	1,563	5.27	£	1,265
Dec	8.72	£	1,902	6.31	£	1,514
	61.85	**£**	**13,483**	**45.98**	**£**	**11,036**

Hydrology & Energy Output Summary

Site Name Mynydd Llandegai - Upper Intake - January 04.10.11 **Date**

Data
FDC: LowFlows with 17l/s additional
Turbine: Cink Crossflow
Generator: IHI / Siemens Induction Generator

Hydrology
Catchment Area: 6.62 sq km
Average Annual Rainfall: m
Evapotranspiration m
Net Runoff: m
ADF: l/s
Residual: Q95 plus 30%

Hydraulics
Gross Head: 11.68 m
Head loss for intake screen: 0.7 m
Pipe Diameter: 0.500 m
Pipe pressure loss (at design flow): 2.7 m
Pipe pressure loss (%): 23%
Net head at design flow: 8.2 m

Turbine
Turbine design flow: 374 l/s
Minimum flow (% of design flow): 15%
Minimum flow: 56 l/s
Derate quoted turbine efficiency by: 2%

Generator
Rating required (kVA) 30
Derate generator efficiency by: 4%

Efficiencies (at design flow)
Pipeline: 77%
Turbine (derated): 81%
Drive / coupling: 96%
Generator (derated): 91%
Transformer: 100%
Transmission: 100%
Design System Efficiency: 54%

% time flow exceeded	**Normalised FDC** l/s	**Total flow** l/s	**Available flow** l/s	**Turbine flow** l/s	**Hydraulic power** kW	**Fraction of design flow**	**Pipeline Eff**	**Turbine Eff** (quoted)	**Turbine Eff** (derated)	**Shaft power** kW	**Generator Eff** (quoted)	**Generator Eff** (derated)	**Electric power** kW	**Available energy** kWHr/yr
5	-	1762	1177	374	40	1.00	77%	83.0%	81.0%	24.0	95.0%	91.0%	22	812
10	-	1341	883	374	40	1.00	77%	83.0%	81.0%	24.0	95.0%	91.0%	22	812
15	-	1089	707	374	40	1.00	77%	83.0%	81.0%	24.0	95.0%	91.0%	22	812
20	-	885	564	374	40	1.00	77%	83.0%	81.0%	24.0	95.0%	91.0%	22	812
25	-	761	477	374	40	1.00	77%	83.0%	81.0%	24.0	95.0%	91.0%	22	812
30	-	654	402	374	40	1.00	77%	83.0%	81.0%	24.0	95.0%	91.0%	22	812
35	-	568	341	341	37	0.91	80%	83.9%	81.9%	23.3	95.0%	91.0%	21	800
40	-	493	289	289	31	0.77	86%	84.2%	82.2%	21.1	95.0%	91.0%	19	752
45	-	431	246	246	26	0.66	90%	84.1%	82.1%	18.8	95.0%	91.0%	17	675
50	-	377	208	208	22	0.56	93%	83.9%	81.9%	16.3	95.0%	91.0%	15	594
55	-	327	173	173	19	0.46	95%	83.4%	81.4%	13.8	95.1%	91.1%	13	511
60	-	284	143	143	15	0.38	97%	82.4%	80.4%	11.5	93.4%	89.4%	10	425
65	-	245	116	116	12	0.31	98%	80.8%	78.8%	9.2	89.0%	85.0%	8	336
70	-	212	92	92	10	0.25	99%	78.5%	76.5%	7.2	82.1%	78.1%	6	250
75	-	182	72	72	8	0.19	99%	75.5%	73.5%	5.4	71.8%	67.8%	4	173
80	-	157	54	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0	0
85	-	130	35	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0	0
90	-	107	19	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0	0
95	-	80	0	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0	0
														9,387

Total Abstraction: **6,187,322** m3/year
Capacity Factor: 0.05 (electrical output)
Max. power output at point of use: **22 kW**
Down time (expected and forced): 2%
Estimated Annual Production: 9 MWh
Generation Tariff: 18.7 p/kWh
Export Tariff: 3.1 p/kWh
Gross income: **£ 2,005**

Hydrology & Energy Output Summary

Site Name Mynydd Llandegai - Upper Intake - July — 04.10.11 **Date**

Data		
FDC:	LowFlows with 17l/s additional	
Turbine:	Cink Crossflow	
Generator:	IHI / Siemens Induction Generator	

Hydrology		
Catchment Area:	6.62	sq km
Average Annual Rainfall:		m
Evapotranspiration		m
Net Runoff:		m
ADF:		l/s
Residual: Q95 plus	50%	

Hydraulics		
Gross Head:	11.7	m
Head loss for intake screen:	0.7	m
Pipe Diameter:	0.500	m
Pipe pressure loss (at design flow):	2.7	m
Pipe pressure loss (%):	23%	
Net head at design flow:	8.2	m

Turbine		
Turbine design flow:	374	l/s
Minimum flow (% of design flow):	15%	
Minimum flow:	56	l/s
Derate quoted turbine efficiency by:	2%	

Generator	
Rating required (kVA)	26
Derate generator efficiency by:	4%

Efficiencies (at design flow)	
Pipeline:	77%
Turbine (derated):	82%
Drive / coupling:	96%
Generator (derated):	91%
Transformer:	100%
Transmission:	100%
Design System Efficiency:	**55%**

% time flow exceeded	**Normalised FDC** l/s	**Total flow** l/s	**Available flow** l/s	**Turbine flow** l/s	**Hydraulic power** kW	**Fraction of design flow**	**Pipeline Eff**	**Turbine Eff** (quoted)	**Turbine Eff** (derated)	**Shaft power** kW	**Generator Eff** (quoted)	**Generator Eff** (derated)	**Electric power** kW	**Available energy** kWHr/yr
5	-	579	277	277	30	0.74	87%	84.2%	82.2%	20.5	95.0%	91.0%	19	695
10	-	349	162	162	17	0.43	96%	83.1%	81.1%	13.0	95.0%	91.0%	12	567
15	-	244	109	109	12	0.29	98%	80.2%	78.2%	8.7	91.1%	87.1%	8	360
20	-	170	73	73	8	0.19	99%	75.7%	73.7%	5.5	78.1%	74.1%	4	216
25	-	135	55	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0	0
30	-	108	42	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0	0
35	-	92	34	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0	0
40	-	79	27	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0	0
45	-	70	22	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0	0
50	-	62	19	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0	0
55	-	56	15	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0	0
60	-	50	13	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0	0
65	-	46	11	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0	0
70	-	43	9	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0	0
75	-	39	7	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0	0
80	-	35	5	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0	0
85	-	32	3	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0	0
90	-	29	2	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0	0
95	-	25	0	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0	0
														1,838

Total Abstraction:	**978,860**	m3/year
Capacity Factor:	0.01	(electrical output)
Max. power output at point of use:	**19**	**kW**
Down time (expected and forced):	2%	
Estimated Annual Production:	**2**	**MWh**
Generation Tariff:	18.7	p/kWh
Export Tariff:	3.1	p/kWh
Gross income: **£**	**393**	

DULAS LTD - HYDROSIZE 2009v2

Hydrology & Energy Output Summary

Site Name Mynydd Llandegai - Lower Intake - January 04.10.11 **Date**

Data

FDC:	LowFlows with 17l/s additional
Turbine:	Cink Crossflow
Generator:	IHI / Siemens Induction Generator

Hydrology

Catchment Area:	6.62	sq km
Average Annual Rainfall:		m
Evapotranspiration		m
Net Runoff:		m
ADF:		l/s
Residual: Q95 plus	30%	

Hydraulics

Gross Head:	9.3	m
Head loss for intake screen:	1.2	m
Pipe Diameter:	0.500	m
Pipe pressure loss (at design flow):	0.8	m
Pipe pressure loss (%):	8%	
Net head at design flow:	7.3	m

Turbine

Turbine design flow:	290	l/s
Minimum flow (% of design flow):	15%	
Minimum flow:	44	l/s
Derate quoted turbine efficiency by:	2%	

Generator

Rating required (kVA)	20
Derate generator efficiency by:	4%

Efficiencies (at design flow)

Pipeline:	92%
Turbine (derated):	81%
Drive / coupling:	96%
Generator (derated):	91%
Transformer:	100%
Transmission:	100%
Design System Efficiency:	**65%**

% time flow exceeded	Normalised FDC l/s	Total flow l/s	Available flow l/s	Turbine flow l/s	Hydraulic power kW	Fraction of design flow	Pipeline Eff	Turbine Eff (quoted)	Turbine Eff (derated)	Shaft power kW	Generator Eff (quoted)	Generator Eff (derated)	Electric power kW	Available energy kWHr/yr
5	-	1762	1177	290	23	1.00	92%	83.0%	81.0%	16.4	95.0%	91.0%	14.9	555
10	-	1341	883	290	23	1.00	92%	83.0%	81.0%	16.4	95.0%	91.0%	14.9	555
15	-	1089	707	290	23	1.00	92%	83.0%	81.0%	16.4	95.0%	91.0%	14.9	555
20	-	885	564	290	23	1.00	92%	83.0%	81.0%	16.4	95.0%	91.0%	14.9	555
25	-	761	477	290	23	1.00	92%	83.0%	81.0%	16.4	95.0%	91.0%	14.9	555
30	-	654	402	290	23	1.00	92%	83.0%	81.0%	16.4	95.0%	91.0%	14.9	555
35	-	568	341	290	23	1.00	92%	83.0%	81.0%	16.4	95.0%	91.0%	14.9	555
40	-	493	289	289	23	1.00	92%	83.1%	81.1%	16.4	95.0%	91.0%	14.9	555
45	-	431	246	246	19	0.85	94%	84.2%	82.2%	14.5	95.0%	91.0%	13.2	522
50	-	377	208	208	16	0.72	96%	84.2%	82.2%	12.4	95.0%	91.0%	11.3	455
55	-	327	173	173	14	0.60	97%	84.0%	82.0%	10.5	95.0%	91.0%	9.5	388
60	-	284	143	143	11	0.49	98%	83.6%	81.6%	8.7	94.7%	90.7%	7.9	324
65	-	245	116	116	9	0.40	99%	82.7%	80.7%	7.0	91.3%	87.3%	6.1	260
70	-	212	92	92	7	0.32	99%	81.0%	79.0%	5.5	85.5%	81.5%	4.5	197
75	-	182	72	72	6	0.25	100%	78.5%	76.5%	4.1	76.2%	72.2%	3.0	139
80	-	157	54	54	4	0.19	100%	75.2%	73.2%	3.0	63.1%	59.1%	1.8	89
85	-	130	35	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
90	-	107	19	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
95	-	80	0	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
														6,814

Total Abstraction:	**5,396,438** m3/year	Max. power output at point of use:	**15 kW**	Generation Tariff:	20.9 p/kWh
Capacity Factor:	0.05 (electrical output)	Down time (expected and forced):	2%	Export Tariff:	3.1 p/kWh
DULAS LTD - HYDROSIZE 2009v2		**Estimated Annual Production:**	**6.7 MWh**	Gross income: £	**1,603**

Hydrology & Energy Output Summary

Site Name Mynydd Llandegai - Lower Intake - July 04.10.11 **Date**

Data
FDC: LowFlows with 17l/s additional
Turbine: Cink Crossflow
Generator: IHI / Siemens Induction Generator

Hydrology
Catchment Area: 6.62 sq km
Average Annual Rainfall: m
Evapotranspiration m
Net Runoff: m
ADF: l/s
Residual: Q95 plus 50%

Hydraulics
Gross Head: 9.3 m
Head loss for intake screen: 1.2 m
Pipe Diameter: 0.500 m
Pipe pressure loss (at design flow): 0.8 m
Pipe pressure loss (%): 8%
Net head at design flow: 7.3 m

Turbine
Turbine design flow: 290 l/s
Minimum flow (% of design flow): 15%
Minimum flow: 44 l/s
Derate quoted turbine efficiency by: 2%

Generator
Rating required (kVA) 20
Derate generator efficiency by: 4%

Efficiencies (at design flow)
Pipeline: 92%
Turbine (derated): 82%
Drive / coupling: 96%
Generator (derated): 91%
Transformer: 100%
Transmission: 100%
Design System Efficiency: **65%**

% time flow exceeded	Normalised FDC l/s	Total flow l/s	Available flow l/s	Turbine flow l/s	Hydraulic power kW	Fraction of design flow	Pipeline Eff	Turbine Eff (quoted)	Turbine Eff (derated)	Shaft power kW	Generator Eff (quoted)	Generator Eff (derated)	Electric power kW	Available energy kWHr/yr
5	-	579	277	277	22	0.96	93%	83.6%	81.6%	15.9	95.0%	91.0%	14.5	538
10	-	349	162	162	13	0.56	97%	83.9%	81.9%	9.8	95.0%	91.0%	8.9	435
15	-	244	109	109	9	0.38	99%	82.3%	80.3%	6.6	90.7%	86.7%	5.7	273
20	-	170	73	73	6	0.25	99%	78.6%	76.6%	4.2	77.8%	73.8%	3.1	164
25	-	135	55	55	4	0.19	100%	75.5%	73.5%	3.1	65.6%	61.6%	1.9	93
30	-	108	42	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
35	-	92	34	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
40	-	79	27	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
45	-	70	22	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
50	-	62	19	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
55	-	56	15	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
60	-	50	13	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
65	-	46	11	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
70	-	43	9	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
75	-	39	7	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
80	-	35	5	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
85	-	32	3	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
90	-	29	2	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
95	-	25	0	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
														1,503

Total Abstraction: **1,065,977** m3/year
Capacity Factor: 0.01 (electrical output)

Max. power output at point of use: **14 kW**
Down time (expected and forced): 2%
Estimated Annual Production: **1.5 MWh**

Generation Tariff: 20.9 p/kWh
Export Tariff: 3.1 p/kWh
Gross income: **£** **354**

Appendix E - Budget Costs

- The following rates are for professional management / engineering time charged at £560/day and a 5% mark-up on materials.
- No allowance has been made for management time or costs incurred by the client, other than those specified.
- Costs are based on previous experience and budget quotes from suppliers and subcontractors – prices for goods or services from other suppliers may vary. No contingency has been included.
- This is not a quotation or tender

Item:	Lower:	Upper:
Project Management		
Project Management	£ 5,479	£ 5,479
H&S, CDM	£ 2,680	£ 2,680
Civil works - surveys, contractual & site supervision	£ 13,945	£ 14,195
Site prelims, mobilisation, compound, welfare etc	£ 5,250	£ 7,875
Intake		
Intake structure detailed design	£ 3,740	£ 3,740
Intake materials & construction	£ 21,000	£ 29,400
Coanda screens	£ 2,600	£ 4,685
Sluice gates, compensation plates, handrails etc	£ 4,655	£ 4,655
Pipeline		
Pipeline design	£ 2,460	£ 2,460
Pipe materials	£ 14,410	£ 31,908
Breather valves & fittings etc	£ 1,400	£ 1,400
Pipe installation (incl signal cable installation)	£ 7,861	£ 25,601
Powerhouse & Outfall		
Powerhouse & outfall design	£ 4,860	£ 4,860
Powerhouse materials & construction	£ 40,029	£ 40,029
Outfall structure & screen	£ 1,365	£ 1,365
Outfall pipe	£ 854	£ 854
Local lights & power, fire & burglar alarm, ventilation	£ 5,179	£ 5,179
Electro-mechanical & Control		
Turbine & generator & spares	£ 41,246	£ 63,920
MIV & auto-close actuator	£ 3,990	£ 5,040
Electromechanical installation	£ 8,105	£ 8,105
Control system installation & certification	£ 2,929	£ 2,929
Cables, glands, etc	£ 1,873	£ 1,873
River level sensor signal cable	£ 481	£ 1,059
Grid Connection		
Grid connection management & site supervision	£ 4,818	£ 5,378
SPEN non-contestable works	£ 600	£ 600
ICP contestable works	£ 13,440	£ 13,440
Commissioning & Desnag		
Commissioing, performance tests, handover & training	£ 4,781	£ 6,461
Optimisation, desnag & warranty (12 months)	£ 7,388	£ 7,388
Total:	**£ 227,417**	**£ 302,557**

Explanation of the variation in costs of the lower intake scheme between Dulas pre-feasibility study and the above estimated costs:

The costs shown in Dulas' pre-feasibility report and the equivalent updated costs are shown in the table below with an explanation of the major changes. The costs shown above include a 5% mark-up on materials, for clarity this has been removed for the comparison below.

Item	Cost	New Cost	Difference	Notes
Turbine - Ecowave	£12,000	£ 39,440	£27,440	1
Valves - MIV and intake chamber	£7,000	£ 5,480	-£1,520	
Generator and control system (SCS)	£5,000	0	-£5,000	2
Intake - design and construction	£25,000	£ 29,180	£4,180	3
Pipeline - DN500 PN6 PE at £50/m and installation estimated at £50/m	£12,000	£ 25,068	£13,068	4
Powerhouse - 4m x 5m design and construction	£30,000	£ 50,242	£20,242	5
Grid connection - metering, witness testing SP engineer, Dulas engineer and equipment hire	£1,600	£ 18,218	£16,618	6
Installation and commissioning	£10,000	£ 39,975	£29,975	7
Project management	£4,000	£ 12,508	£8,508	7
Total:	£106,600	£ 220,112	£113,512	

Notes:

1. Turbine manufacturer changed to Cink Hydro-Energy and cost includes turbine, gearbox, generator and control system. In addition as the manufacturer is in mainland Europe, an allowance has been included for overseas shipment and customs. The quotation is in Euros and the exchange rate on 16.09.11 has been used, this is subject to variation and the final price will depend on the exchange rate at the time of purchase.
2. This is now included in the 1st line.
3. Having completed an outline design, the intake structure is larger than originally anticipated.
4. On the manufacturer's recommendation, the pipe wall thickness has been increased to prevent mechanical damage. This has resulted in a 12% increase in price. The remainder of the difference is due to general increases in pipe costs and detailed investigation of anchoring requirements. (HPPE pipe costs are closely linked to the current price of oil).
5. The powerhouse is larger and requires a more substantial turbine sump than originally anticipated.
6. A single phase connection was originally envisaged. This has been revised and the additional costs is to re-conductor the existing overhead line and add a new telegraph pole.
7. These two items are priced on Dulas' 2011 rates and now assume Dulas is carrying out all the project management / supervision work rather than assuming Coetir Mynydd would carry out some of this work. £10,000 of these costs is made up of Dulas employees travel and accommodation costs.

CINK Hydro - Energy k.s.
Lesov 125, Sadov
360 01, Česká republika

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Telefon: +420-353 579 154
E-mail: cink@cink-hydro-energy.com
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Mr. Will Handford
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Unit 1, Dyfi Eco Park, Machynlleth
SY208AX N.Wales
Tel: +44 654 705 013
E-mail: will.hadnford@dulas.org.uk

Karlovy Vary 16th September 2011

Preliminary offer No. 2563/UK Project: MYNYDD LLANDEGAI

Dear Mr. Handford,

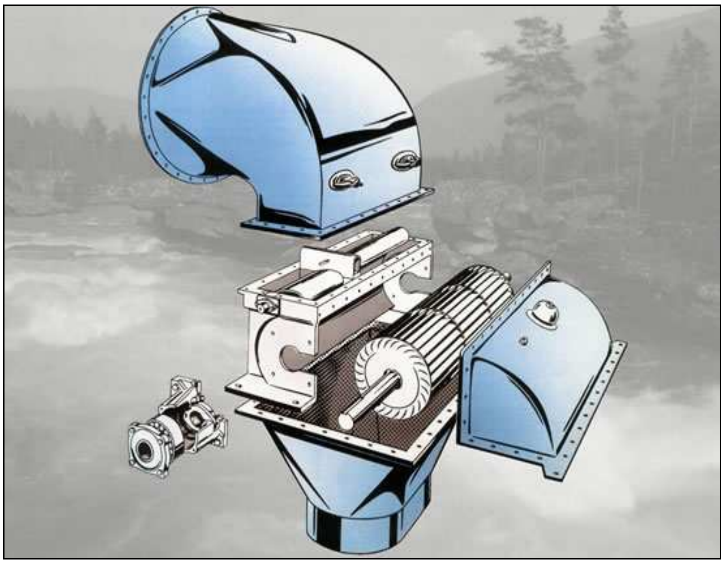
With reference to your demand we have the pleasure to offer you the hydroelectric unit/equipment as follows.

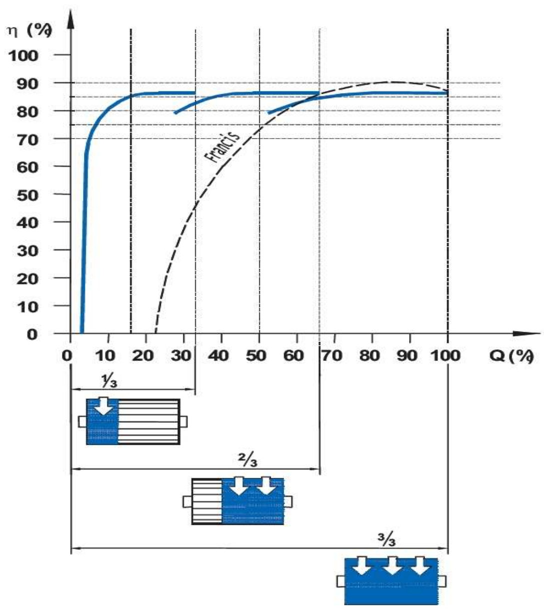
Subject:

Delivery of one fully automated Small Hydro-Power-Plant (SHPP) for unmanned operation with a

CROSSFLOW-TURBINE

Due to the singular 2-cell construction this kind of turbine operates with highest efficiency from 17%-100% of design flow. It requires almost no maintenance and has been proved in nearly 10.000 places of more than 110 countries worldwide.





Operating Conditions:

Keeping the level in the tank in front of the inlet pipe constant, SHPP shall control the flow rate by generating electrical energy. SHPP will operate parallel to the public electric network and feed in the produced energy.
It is fully automated and requires only occasional supervision attendance (to lubricate the bearings etc.).
The control system incorporating a programmable automatic machine (PLC) contains all information and checking levels ensuring safe operation, high level of efficiency and reliability of the SHPP. Furthermore it contains interface for remote communication of the SCADA conception with the possibility of remote transmission of instructions and signaling.

Hydraulic Characteristics:

Gross head	H_b	=	13,80	m
Pipe length	L	=	330,00	m
Hydraulic losses	$\sum_t$	=	2,90	m
Net head	H_{net}	=	10,90	m
Flow rates: maximum flow rate at H_{net}	Q_{max}	=	370	l/s
minimum flow rate at H_{net}	Q_{min}	=	63	l/s
minimum flow rate outside below mentioned guarantee range	Q	=	22	l/s

The Purchaser will guarantee that the a. m. heads and flow rates will not change. Purchaser will also guarantee that the pipe all over its longitude holds general service pressure 1 bar. The pipe has to be installed straight, without peaks and bends and may not exert any forces, pressures and vibrations to the SHPP.

Technical Parameters:

Guaranteed performance based on the hydraulic data.

Flow rate	**100%**	**90%**	**60%**	**30%**	**17%**
Output kW	32	29	20	10	5
Flow rate l/s	370	333	222	111	63
Efficiency in % (ή)	**82**	**82**	**82**	**81**	**80**

Output Turbine max.: **32 kW**
Output Generator max.: **29 kW**

Scope of delivery:

Turbine with accessories

- 2 – cell Crossflow-turbine, SH3.049/6g
- revolutions 413/min, revolutions max. 1.053/min
- inlet pipe
- draft tube 2 m long

Note:
- Environmental conditions of location:
  - maximum altitude 1000 m above sea level
  - temperature from 0℃ up to + 40 ℃
  - maximum humidity 90 % at 30 ℃

- base plate frame
- emergency shutdown weights (gravimetric)
- sensors for revolution scanning and guide vane position
- hydraulic aggregate including the hydraulic cylinders and oil charge

Gearbox / Couplings

- gearbox with oil cooling
- temperature sensor 1 x PT100
- anchors for gearbox
- couplings between the turbine, gearbox and generator
- oil charge
- protection covers of rotating parts

Generator

- asynchronous generator
- nominal output PN = 29 kW
- nominal revolutions 1.020/ min., revolution max. 2.600/min (15 min)
- frequency 50 Hz, tension 415 V
- protection IP 55, cooling IC 01, insulation category F/B
- anti-condensation heater
- temperature sensors (winding, bearings - 5 x PT100)
- anchors for generator

Control system

- will ensure unmanned operation of SHPP parallel with the public electric network
- option of manual operation
- automatic five-step compensation of idle output,
  rated output installed 19 kVAr/415V, regulation of cos φ 0,85 – 0,98
- SIMATIC in required configuration I/O
- 5,7 monochromatic LCD panel in touch screen design
- breakdown automatics (will ensure the shut-down of SHPP in case of failure identification and its starting up after the failure termination)
- voltage supply for control system (UPS)
- interface for remote control and signaling (GSM modem)
- communication cable (Cu) between turbine and control system
- pressure water level sensor 0-2,5 m/ 4-20 mA, including its holder
- connection cable between water level sensor and control system not included (must be laid down together with the pipeline installation)

Switchboard, 415 V, 50 Hz

- protections against: under voltage, over voltage, frequency, over current, reverse watt surge, current asymmetry
- main generator switches and a network analyser
- power cable between generator and switchboard (Al) – not included

Accompanying Documentation :

- cross-section diagram of the SHPP;
- drawings on the disposition of all supplied equipments in the machine room and next to the machine room, including the specification of sizes for the location of equipment;
- automation chart including the quantity of protections;
- other characteristic cross-sections considered by the supplier to be necessary in order to determine the proportions of the SHPP, including the part of the inlet;
- load and maximum proportions for transportation and handling;
- necessary documents during assembly and operation, during maintenance and repairs;
- technical documentation, certificates of quality and guarantee, operating and maintenance manual in ENGLISH
- declaration of conformity

Guarantee:
The guarantee for the SHPP is 24 months after putting into operation, maximum 30 months after delivery.

Price for SHPP : **Eur 59.500,--**

without VAT, **FCA Sadov (Incoterms 2010)**, packed, without supervision of made assembly and putting into operation.

This offer does not contain price for transformer and output extraction. For consumer it is preferable to ensure it with operator of local electrical network.

Payment terms:
40% after contract signing
60% when the goods are ready for dispatch

Delivery term: 6 months

Validity of the offer: 12 weeks

We stay at your disposal with any further information.

Yours sincerely,

Dr. Ing. Daniel Maass
Managing Director

Appendix F - Power & Energy Calculations for a 5kW Scheme

Hydrology & Energy Output Summary

Site Name Mynydd Llandegai - Lower Intake - 5kW scheme - April - November 08.11.11 **Date**

Data

FDC:	LowFlows with 17l/s additional
Turbine:	Cink Crossflow
Generator:	IHI / Siemens Induction Generator

Hydrology

Catchment Area:	6.62	sq km
Average Annual Rainfall:		m
Evapotranspiration		m
Net Runoff:	1.779	m
ADF:	374	l/s
Residual: Q95 plus	50%	

Hydraulics

Gross Head:	9.3	m
Head loss for intake screen:	0.7	m
Pipe Diameter:	0.355	m
Pipe pressure loss (at design flow):	0.4	m
Pipe pressure loss (%):	4%	
Net head at design flow:	8.2	m

Turbine

Turbine design flow:	88	l/s
Minimum flow (% of design flow):	15%	
Minimum flow:	13	l/s
Derate quoted turbine efficiency by:	2%	

Generator

Rating required (kVA)	7
Derate generator efficiency by:	4%

Efficiencies (at design flow)

Pipeline:	96%
Turbine (derated):	81%
Drive / coupling:	96%
Generator (derated):	91%
Transformer:	100%
Transmission:	100%
Design System Efficiency:	**68%**

% time flow exceeded	**Normalised FDC** l/s	**Total flow** l/s	**Available flow** l/s	**Turbine flow** l/s	**Hydraulic power** kW	**Fraction of design flow**	**Pipeline Eff**	**Turbine Eff** (quoted)	**Turbine Eff** (derated)	**Shaft power** kW	**Generator Eff** (quoted)	**Generator Eff** (derated)	**Electric power** kW	**Available energy** kWHr/yr
5	-	1178	575	88	7	1.00	96%	83.0%	81.0%	5.5	95.0%	91.0%	5.0	1,461
10	-	746	359	88	7	1.00	96%	83.0%	81.0%	5.5	95.0%	91.0%	5.0	1,461
15	-	548	259	88	7	1.00	96%	83.0%	81.0%	5.5	95.0%	91.0%	5.0	1,461
20	-	402	187	88	7	1.00	96%	83.0%	81.0%	5.5	95.0%	91.0%	5.0	1,461
25	-	319	145	88	7	1.00	96%	83.0%	81.0%	5.5	95.0%	91.0%	5.0	1,461
30	-	253	112	88	7	1.00	96%	83.0%	81.0%	5.5	95.0%	91.0%	5.0	1,461
35	-	207	89	88	7	1.00	96%	83.0%	81.0%	5.5	95.0%	91.0%	5.0	1,461
40	-	170	71	71	6	0.80	97%	84.2%	82.2%	4.5	95.0%	91.0%	4.1	1,334
45	-	144	58	58	5	0.65	98%	84.1%	82.1%	3.7	95.0%	91.0%	3.4	1,100
50	-	122	47	47	4	0.53	99%	83.8%	81.8%	3.0	95.0%	91.0%	2.8	899
55	-	104	38	38	3	0.43	99%	83.0%	81.0%	2.4	92.1%	88.1%	2.1	716
60	-	89	30	30	3	0.34	99%	81.6%	79.6%	1.9	86.5%	82.5%	1.6	544
65	-	77	24	24	2	0.27	100%	79.6%	77.6%	1.5	79.0%	75.0%	1.1	395
70	-	67	19	19	2	0.22	100%	76.9%	74.9%	1.1	68.7%	64.7%	0.7	273
75	-	58	14	14	1	0.16	100%	73.7%	71.7%	0.8	55.2%	51.2%	0.4	171
80	-	50	11	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
85	-	42	7	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
90	-	36	4	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
95	-	29	0	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
														15,660

Total Abstraction:	**965,176**	m3/season
Capacity Factor:	0.52	(electrical output)
Max. power output at point of use:	**5**	**kW**
Down time (expected and forced):	2%	
Estimated Annual Production:	**15.3**	**MWh**
Generation Tariff:	20.9	p/kWh
Export Tariff:	3.1	p/kWh
Gross income:	**£ 3,683**	

Hydrology & Energy Output Summary

Site Name Mynydd Llandegai - Lower Intake - 5kW scheme - Dec - March 08.11.11 **Date**

Data

FDC:	LowFlows with 17l/s additional
Turbine:	Cink Crossflow
Generator:	IHI / Siemens Induction Generator

Hydrology

Catchment Area:	6.62	sq km
Average Annual Rainfall:		m
Evapotranspiration		m
Net Runoff:	1.779	m
ADF:	374	l/s
Residual: Q95 plus	30%	

Hydraulics

Gross Head:	9.3	m
Head loss for intake screen:	0.7	m
Pipe Diameter:	0.355	m
Pipe pressure loss (at design flow):	0.4	m
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Net head at design flow:	8.2	m

Turbine

Turbine design flow:	88	l/s
Minimum flow (% of design flow):	15%	
Minimum flow:	13	l/s
Derate quoted turbine efficiency by:	2%	

Generator

Rating required (kVA)	7
Derate generator efficiency by:	4%

Efficiencies (at design flow)

Pipeline:	96%
Turbine (derated):	81%
Drive / coupling:	96%
Generator (derated):	91%
Transformer:	100%
Transmission:	100%
Design System Efficiency:	**68%**

% time flow exceeded	**Normalised FDC** l/s	**Total flow** l/s	**Available flow** l/s	**Turbine flow** l/s	**Hydraulic power** kW	**Fraction of design flow**	**Pipeline Eff**	**Turbine Eff** (quoted)	**Turbine Eff** (derated)	**Shaft power** kW	**Generator Eff** (quoted)	**Generator Eff** (derated)	**Electric power** kW	**Available energy** kWHr/yr
5	-	1757	1178	88	7	1.00	96%	83.0%	81.0%	5.5	95.0%	91.0%	5.0	730
10	-	1232	811	88	7	1.00	96%	83.0%	81.0%	5.5	95.0%	91.0%	5.0	730
15	-	980	634	88	7	1.00	96%	83.0%	81.0%	5.5	95.0%	91.0%	5.0	730
20	-	779	494	88	7	1.00	96%	83.0%	81.0%	5.5	95.0%	91.0%	5.0	730
25	-	652	405	88	7	1.00	96%	83.0%	81.0%	5.5	95.0%	91.0%	5.0	730
30	-	546	330	88	7	1.00	96%	83.0%	81.0%	5.5	95.0%	91.0%	5.0	730
35	-	467	275	88	7	1.00	96%	83.0%	81.0%	5.5	95.0%	91.0%	5.0	730
40	-	399	228	88	7	1.00	96%	83.0%	81.0%	5.5	95.0%	91.0%	5.0	730
45	-	344	189	88	7	1.00	96%	83.0%	81.0%	5.5	95.0%	91.0%	5.0	730
50	-	297	156	88	7	1.00	96%	83.0%	81.0%	5.5	95.0%	91.0%	5.0	730
55	-	256	128	88	7	1.00	96%	83.0%	81.0%	5.5	95.0%	91.0%	5.0	730
60	-	221	103	88	7	1.00	96%	83.0%	81.0%	5.5	95.0%	91.0%	5.0	730
65	-	193	83	83	7	0.94	96%	83.7%	81.7%	5.3	95.0%	91.0%	4.8	715
70	-	168	66	66	6	0.75	98%	84.2%	82.2%	4.3	95.0%	91.0%	3.9	632
75	-	147	51	51	4	0.58	99%	83.9%	81.9%	3.3	95.0%	91.0%	3.0	503
80	-	128	38	38	3	0.43	99%	83.1%	81.1%	2.5	92.2%	88.2%	2.2	378
85	-	110	25	25	2	0.28	100%	79.9%	77.9%	1.6	80.4%	76.4%	1.2	245
90	-	94	14	14	1	0.16	100%	73.3%	71.3%	0.8	53.7%	49.7%	0.4	116
95	-	74	0	0	0	0.00	0%	0.0%	0.0%	0.0	0.0%	0.0%	0.0	0
														11,355

Total Abstraction:	**696,531** m3/year	Max. power output at point of use:	**5 kW**	Generation Tariff:	20.9 p/kWh
Capacity Factor:	0.77 (electrical output)	Down time (expected and forced):	2%	Export Tariff:	3.1 p/kWh
DULAS LTD - HYDROSIZE 2009v2		**Estimated Annual Production:**	**11.1 MWh**	Gross income: **£**	**2,671**