Galedffrwd MHP
Pre-feasibility Report

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Client: Coetir Mynydd

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Executive Summary

This feasibility study examines the potential for hydro electric generation on the river Galedffrwd. Two schemes have been examined at the pre-feasibility level.

The smaller scheme would conveniently be rated at 12 or 15kW in order to maximize income yield from the scheme whilst minimizing the capital costs of developing the scheme. This scheme is based upon abstraction from the existing impoundment and feeding water down to the corner of the land purchased by Coetir Mynydd where the power plant would be located. Generation is put at 43Mhr/y and gross income, before operating costs, is put at £9,932. The scheme design and installation is estimated to be around £110,000.

The larger scheme would be rated at 100kW and yield some 430MWh/y representing a gross income of £89,535 and estimated cost of £553,000. There are a number of options for the plant and considerable technical issues that will need addressing before this option could be progressed.

Each of these schemes presents potential options to provide an income for Coetir Mynydd community group from hydro electricity. For the smaller scheme, all equipment would belong to Coetir Mynydd and hence all profit would go directly to them. For the larger scheme, there maybe scope for the community to own the plant, or alternatively an external investor could be used. If an investor is used, they would own and operate the plant but Coetir Mynydd would receive rent for use of their land for the powerhouse. There maybe potential for both schemes to work, though this needs further investigation.

Disclaimer
Dulas Ltd have endeavoured to ensure that the information contained in this report is accurate. However, Dulas Ltd. accepts no liability for the use of this information.

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 feasibility work carried out on two options for a hydro scheme development both of which would utilise reaches of Afon Geladffrwd near Mynydd Llandegai (OS Land ranger OL17, powerhouse grid ref approximately SH 6146 6630). The smaller scheme is hereafter called the ‘dam scheme’ and the larger is referred to as the ‘Geladffrwd scheme’ for convenience. The work essentially comprises the following:

- Site survey results
- Scheme layout options
- Hydrological summary
- Consultation regarding abstraction, planning and environmental issues
- Turbine and other equipment options
- Predicted power and energy output for multiple options
- Grid connection issues
- Budget implementation costs
- Power purchase and predicted income
- Recommendations

2 Site Survey & Scheme Layout Options

A site survey was carried out on the 15th February 2010. Initially, the dam scheme was surveyed to identify the best locations for the intake and powerhouse. Levels were then measured using a builder’s level to establish the gross head of the dam scheme. An assessment of possible pipeline routes was undertaken, along with access routes into and around the site and the best method of connecting to the grid.

Following this, the Geladffrwd scheme was investigated further. This included walking the river upstream of the bridge at SH 605 656 to look for possible intake locations and an initial look at options for the pipeline route.

A second survey was carried out on the 12th May 2010. This was to meet with the Environment Agency (EA) to discuss ecological issues and water abstraction. A more detailed survey of the pipeline route for the Geladffrwd scheme was also done.

2.1 Intake Sites

2.1.1 Dam scheme

Coetir Mynydd’s original assumption regarding the intake for the dam scheme is that it would utilise the existing draw off pipe at the dam wall and that this would be screened with bars. Because the impoundment is bordered by deciduous trees, there is likely to be a considerable and varied screening load on the intake and Dulas’ experience is that frequent blocking at the intake is likely to severely impact energy yield and increase operational maintenance effort. For this reason, Coanda type intakes are recommended. Coanda screens are widely used for intakes of small hydro schemes, being largely self cleaning and requiring no external source of power supply. A cheaper alternative would be to use a perforated metal sheet. These options are discussed in more detail later in the report.

A new channel would be dug in the corner of the reservoir furthest from the road. This area of the reservoir would need to be cleared of vegetation for construction and to limit screen blocking. A new weir to incorporate the screens would be made from reinforced concrete, with the base slab tied into the bedrock where present. Wing walls would be designed to cope with flood levels as appropriate, and there would need to be bank and scour protection put in place. This is usually done with gabions and boulders in mass concrete if there is no bedrock.

This would mean no major construction would be required on the existing dam weir. However some minor modifications would be needed as this would be the logical location for the Q95 and additional flows that are required to stay in the river.

Proposed intake location at corner of reservoir

2.1.2 Galedffrwd scheme

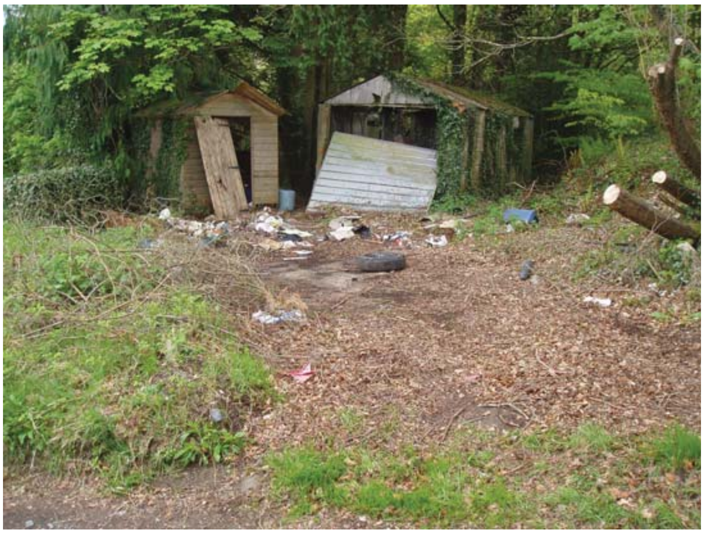
Any intake for the larger Galedffrwd scheme would be on land not owned by Coetir Mynydd which adds complications with land ownership agreements. The optimum intake location would be at the ruins of an old dam just upstream from a road bridge at SH 6060 6545.

A second site was also investigated to locate the Galedffrwd intake near a foot bridge at SH 611 659. This site was discarded due to poor access and unsuitable bedrock or features on which to build the intake. The gross head would also be 50-60 meters less, effectively halving the power available.

Remains of old dam for Galedffrwd scheme intake

2.2 Powerhouse Sites

For both schemes the optimum powerhouse location would be at the far end of the Coetir Mynydd land where a track comes off the main road at SH 615 663. There are two existing structures in poor condition just off the track. If these were removed and the area cleared it would leave open level ground on which to build a new powerhouse. This space is several meters above the river which could reduce available head but will protect the plant when the river is in flood. Some or all of the head between the powerhouse and river below could be captured, depending on what type of turbine is used.

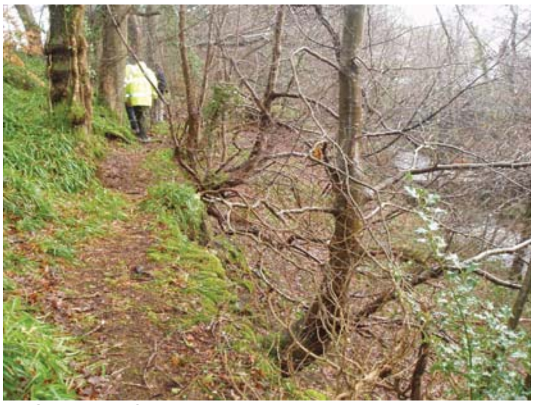


Existing structures at proposed powerhouse location

2.3 Pipeline route

2.3.1 Dam scheme

As long as the intake is on the same side of the river as the powerhouse then there is a fairly simple pipe route through the trees along the river bank, a few meters above the normal river level. There is an existing pathway for part of the route that could be utilised but it is likely that some trees will have to be removed to make way for the pipeline. Following on site consultation, the EA are happy with this proposal and Tecwyn Evans of the EA confirmed that the pipeline did not need to be buried. This will make installation simpler and cheaper but as far as the EA are concerned the main reason is that it will also cause less damage to the woodland.



Section of proposed pipeline route utilising existing path through woods

Old dam where tailrace must discharge

For both schemes there will need to be a tailrace pipeline from the powerhouse to discharge water into the river. Conditions of abstraction agreed with the EA on site were that all water would discharge to the river at the remains of an old dam near the proposed powerhouse location as this is the highest point of the river that migratory fish could reach. The dam is about 12m upstream from the proposed powerhouse location so the pipeline will have to run back on itself in order to discharge at the correct location. Discharging further down stream would reduce the available annual abstraction by 10%.

2.3.2 Galedffrwd scheme

This pipeline route is much longer and more complicated. The intake and powerhouse are roughly 1.25km apart as the crow flies but the pipeline would be slightly longer. The initial problem is getting enough inclination on the pipeline immediately after the intake chamber (to permit the necessary discharge), as the surrounding ground is fairly level. Assuming this can be done, the pipeline then needs to cross an elevated road bridge about 100m down stream of the proposed intake site. It is unlikely that the existing tunnel under the bridge is large enough to house the pipeline as it is already undersized for the river. It may be possible to bore a new tunnel through the bridge to accommodate the pipe but this would require structural investigations to confirm.

Once beyond the bridge, the pipeline could potentially run on either side of the river. On river right, as looking down stream, a single field could potentially be used for 500-600m up to the road. From here the easiest route would be under the road. The highways authority will need to be consulted if the pipe is the follow the road and there are already pipes running along the same road which will need to be avoided. These belong to Dwr Cymru and supply the water treatment works at Mynydd Llandegai. At the end of the route the pipeline would have to be dug into the access track over the river which leads to the proposed powerhouse location. If this is not possible, another route across the river would have to be found.

On river left, the pipeline would run cross country all the way to the powerhouse. This would involve several landowner agreements for permission to lay the pipe. This would be on steep ground for the first half and access could be difficult.

A much more detailed survey and investigation of the pipeline route for this scheme will be required at the detailed feasibility level to ascertain whether a possible route exists.

2.4 Construction Access

Access to the proposed powerhouse location, where most large equipment will need to be installed, is via tarmac roads with the final 100m or so of hard standing track designed for vehicle use.

2.4.1 Dam Scheme

The intake and pipeline route can be accessed by a public footpath which may have to be closed off during construction. The path should require little or no modifications although a kissing gate will have to be temporarily removed to allow access for small diggers or powered barrows. The pipeline is short and presents little in the way of difficulties for installing the material, despite the pipes relatively large diameter.

2.4.2 Galedffrwd Scheme

Access to the proposed intake is also by tarmac road with the exception of the last hundred meters or so which will be over unimproved pasture/fields. Access to the pipeline route may be problematic. If the pipeline ran along the road side then access will be good for the majority of the route, until the pipe needed to cross the river. If the pipeline ran along the other side of the river then access would be a continuous issue that needs more detailed investigation.

2.5 Landowner Issues

2.5.1 Dam Scheme

It is understood that there are no land owner issues as Coetir Mynydd has purchased the strip of riparian land from the bridge up to the dam itself and beyond.

2.5.2 Galedffrwd Scheme

The intake and much of the pipeline will lie upon land owned by third parties. Where an intake is located at the boundary of two land owners, a typical arrangement with the third party landowner is to offer a percentage of generated income in return for use of their land and carrying out simple monitoring and maintenance of the intake screens. A simpler arrangement can usually be reached with landowners to house the pipeline. However agreements can not always be reached and the more landowners involved, the more likely the chance that someone will not allow use of their land.

3 Hydrology & Abstraction

3.1 Hydrology

3.1.1 Dam Scheme

Coetir Mynydd installed a level sensor at the dam in order to derive discharges over the dam spill using an estimated figure for the coefficient of discharge. Dam level data measurements were thereby recorded between the 21st May 2006 and 21st May 2007 at hourly intervals. Dulas has checked this data and believes that the derivation of discharge from the raw data is of an acceptable accuracy to be used for a first level flow duration curve. Using this discharge data, Dulas has generated a flow duration curve that has been used as the basis of the energy study shown in Appendix B. It should be noted that basing the flow duration curve on just one year of data can only be justified in this case by the fact that the scheme being proposed is de-rated from what is potentially possible and that the measured data is similar enough to the average flow value given by the EA.

If the dam scheme is to be progressed at a detailed feasibility level, it may be prudent to obtain the flow duration data based on long term rainfall data using the Lowflows[1] software. This software uses long term data from a nationwide network of river gauging stations and is generally considered to be the best source of discharge data for energy generation calculations for small catchments.

3.1.2 Galedffrwd Scheme

A software programme called HydrA has been used to generate a flow duration curve. HydrA was developed by Wallingford Hydro Solutions just as Lowflows software is and gives similar results. The natural catchment area of the Galedffrwd has been modified to allow for the man-made features that will affect the hydrology. Specifically, the catchment of Marchlyn Mawr Reservoir (which nominally drains into the Galedffrwd), has been excluded as has been the edges of the catchment area that lie on Penrhyn Slate Quarry. However only a single flow duration curve has been generated on HydrA that shows and average year. Conditions of abstraction given by the EA suggest that a greater amount of water can be taken from the river between January and March. Therefore the HydrA information has been compared to a Lowflows analysis on the Afon Llafar, south east of Bethesda. This is of similar altitude in the same area and the Lowflows provides average monthly data. Using an appropriate multiplication factor for catchment size, the Lowflows data has been used for predicted energy generation.

Due to the nature of the man-made features that fall within the catchment area and the means of obtaining monthly data, the energy generation figures given in Appendix B must be treated with care.

3.2 Abstraction License

Abstractions in Wales are regulated by the Environment Agency. The EA issue permits for the abstraction, impoundment (due to the weir and intake) and for working in the river.

Application fees of around £700 are payable for these licences, including the newspaper advertisements, which the EA place on the developers behalf.

The Abstraction licence will specify how much water can be taken from the river, and is therefore fundamental to the viability of any hydro scheme.

3.3 EA Consultation

The EA carried out an initial assessment of the site on 12th May 2010. It was confirmed that the river is used by migratory fish but there is no substantial bryophyte

[1] http://www.hydrosolutions.co.uk/lowflows1.html

colonisation or other ecological factors that may affect the abstraction levels. On inspection of the dam and weir, it was proposed that the permitted abstraction will be 50% of the available flow left after arranging for the permanent “Q95” residual flow in the river. This was mainly due to the assumption that the dam is the furthest point up river the migratory fish could get. It was also stated that an additional 10-20% would be available for abstraction between January and March.

On further inspection the EA concluded that lower dam near the proposed powerhouse location is the furthest point that migratory fish could reach and if all discharge was at this dam then 60% abstraction above the Q95 residual flow would be permitted. This still includes the additional 10-20% between January and March and in a later e-mail, Tecwyn Evans of the EA suggested that the increase might be extended until the end of April.

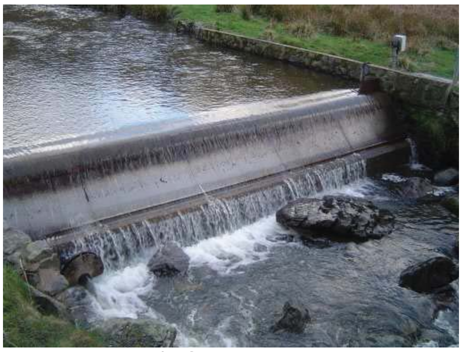
The seasonal abstraction proposed above makes the energy generation calculations more complicated, as monthly assessments are required, rather than an annual calculation.

3.4 Intake Design

3.4.1 Dam Scheme

After some analysis, it is proposed to set the design discharge at 300l/s for a Crossflow turbine or 165l/s for a commercially available Propeller Turbine. 4.5m of Coanda screens would be needed for 300l/s and 2.5m for 165l/s costing roughly £6,000-£8,000 and £4,000-£5,000 respectively. This assumes that a ‘quarter height’ high capacity version of the screen is used which has wedge wire spacing of 2mm as opposed to the standard 1mm spacing. Whilst the screening is slightly less effective compared to the standard screen, there is no detriment to turbine operation however there is a gain to net head, which is at a premium for the dam scheme. A cheaper option would be to use perforated metal sheets at around £1,000. These are not only cheaper but would also reduce net head loss for the intake. The disadvantage of perforated sheets is they are much more prone to blocking so require much more regular maintenance. Note that, in either case, the screen cost is a small part of the complete intake design and construction cost.


600l/s Perforated sheet installation


500l/s Coanda installation

The screens would be located on the new weir in the corner of the reservoir as previously mentioned. A chamber would be located adjacent to the screens near the existing fence and a channel dug between the two for water to flow. The chamber should be arranged so that the screen sump can be isolated from the screens so that the chamber can be drained to allow the pipeline to be cleaned from time to time. A new spillway would need to be created below the screens to direct additional water back into the river at the base of the dam. The pipeline would be connected directly to the intake chamber.

Taking the example of using Coanda screens to abstract 300l/s, the screens would be 4.5m long, 400mm high and 695mm wide. A 1.2m deep sump would be required below the screens to convey water to the intake chamber. A minimum sump cross sectional area of 600mm^2 would be needed between the channel and the chamber.

A notch would be used to guarantee the Q95 discharge. This could be next to the intake screening at the new weir but for aesthetic reasons it may be better located in the existing weir. The existing weir crest would be modified with new casting to incorporate the Q95 notch and the weir spill length would be arranged to allow the additional 40% flow to bypass the screens. A removable spacing block could be used to decrease the spill length for the months of the year when only an additional 20% of river discharge needs to bypass the screens. Dimensions, elevations and suitable ground investigations are required before detailed design of the intake can begin.

3.4.2 Galedffrwd Scheme

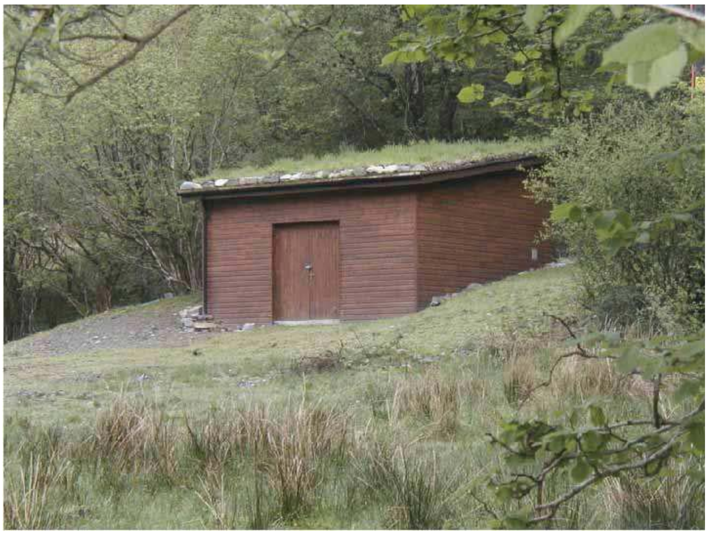
Design discharge for the Galedffrwd scheme is suggested to be around 150l/s. This would require 1m of ‘full height’ or 2m of ‘half height’ Coanda screen built into the original dam structure. These screens are 1.2m and 700mm high respectively. The standard 1mm wedge wire spacing would be specified. A sump channel under the screen(s) leading to the intake chamber would be needed similar to the Dam scheme. A pipe/orifice arrangement in the weir structure may be the most practical (cf. Vee notch weir) way of providing the Q95 residual discharge due to the restriction in width. Ideally the water level upstream of the old dam would be raised slightly to aid intake design. This would have to be negotiated with the land owner.

4 Planning & Environmental

Details of the scheme were sent to the Gwynedd Council who are the relevant planning authority, as well as the EA. A site meeting was also held the EA and a member of Coetir Mynydd to discuss the options.

4.1 Landscape & Visual Impact

The powerhouse will be roughly the size of a garage or slightly larger and also higher if a gantry is to be installed. The exact footprint will depend on the turbine chosen. The proposed location for the powerhouse is on land owned by the community group and is mainly surrounded by trees. The area is currently waste ground with an old shed with rubbish inside and out. Any new structure is unlikely to have much visual impact given the geography and ecology around the location. It is sometimes required to construct some powerhouses with timber or stone cladding and turf or slate roof, subject to planning. It is not expected that planning will go into such detail for this site but this can be a good way of matching a new building to the existing area. A photo of a 200kW site with timber clad walls and turf roof is shown below.


200kW Pelton turbine powerhouse

The river intake civil works will also have a limited impact visually but this is much less so for the dam scheme as the basic infrastructure is already in place. The planning application should cover both power house and all other civil works.

4.2 Reservoirs act compliance

It is understood that the reservoir above the upper dam does not come under the reservoirs act. If this is not the case then a Flood Defence Consent (FDC) application and quite possibly Flood Consequence Assessment (FCA) will be needed from the EA who is the relevant authority.

4.3 Planning Application

Initial contact has been made but formal applications will need to be submitted to the EA and Gwynedd Council for abstraction and planning. Several surveys, including archaeological, flora and fauna, may need to be completed as part of the supporting evidence for the application. This will be determined by the EA and Gwynedd Council.

The supporting evidence document should address planning related issues, and also the benefits of renewable energy on a national scale. It should outline the environmental impact (referencing the survey results) and should also include outline construction method statements and an environmental management plan. Outline drawings of the intake and powerhouse, plus photomontages if required should also be included. These documents will also form the majority of the abstraction and impoundment licence applications.

The cost of compiling the supporting evidence for such a planning application is typically £3,000 to £5,000, plus the cost of the surveys. A budget of £1,500 should be sufficient to cover the Planning application fee and related work.

Usually the Planning application is submitted in conjunction with the abstraction/impoundment licence applications, once all parties are happy with the proposal. Both applications will typically take 3-4 months to process.

5 Equipment Options

5.1 Turbine

5.1.1 Dam Scheme

The low head option of the dam scheme is probably best suited to a crossflow turbine. Crossflow turbines use a guide vane to control the discharge of water through the turbine. A marginal amount of 'suction head' can be created in the draft tube which enables slightly more of the potential gross head to be utilised. Crossflow turbines have acceptable performance across a wide range of discharges.

An alternative option would be a propeller turbine. A commercially available machine suitable for this scheme has recently become available. With a propeller turbine, the full potential head of the site can be exploited. If a propeller turbine was used at this site, the gross head would be from the intake top water level to the tailrace pond water level. Propeller turbines only really operate at design efficiency at or near the design discharge. Their performance at the design point is considerably better than possible with a crossflow turbine.

Despite the limitations of the Propeller turbine, an analysis has shown that the annual energy generation is only marginally less than a crossflow turbine with the propeller turbine using significantly less water.

For the crossflow turbine, supply could be Ecowave Systems (UK) or perhaps Heksa Hydro an Indonesian supplier. Dulas have not worked with Ecowave so build quality and reliability are unknown. Heksa turbines have been used in Wales which are cheaper and well built. However there is extra cost in shipping plus time and cost involved with detailed specification and management of ordering which could make them more expensive. The propeller turbine referred to above would be supplied via Gilkes who the authorised distributor of Cargo & Kraft (Sweden).

5.1.2 Galedffrwd Scheme

This site is suitable for a single jet Turgo turbine however, a 2-jet Pelton turbine would also be possible. For Turgo and Pelton turbines, a deflector plate can be used to mitigate pipeline pressure surge issues. A Turgo machine would almost certainly be sourced from Gilkes but there is a wider range of possible suppliers for Pelton turbines.

5.2 Valves

As well as the control valves/vanes on the turbine, there will be a main inlet valve (MIV) in the powerhouse to close off the pipe and isolate the turbine. In addition there will be a manually operated valve or sluice gate at the intake which can be used for maintenance purposes or emergencies.

Valves and vanes can be controlled manually, electrically or hydraulically, and it is usual for the MIV to have either a failsafe weight closure or battery back-up to permit operation in the event of loss of mains. There are a variety of small pros and cons in terms of operating hydraulic and electric systems notably hydraulic systems require more regular maintenance (filters, solenoids, etc) and oil leaks are a potential hazard.

5.3 Generator

The main choice is between a synchronous and induction machine.

Induction generators (essentially motors) are simpler, cheaper, more robust, and generally withstand being operated at 'over speed' well. They require a capacitor bank to control power factor.

In terms of speed, it is usual to match the turbine and generator to give direct drive, as gear boxes or belts add complexity and require additional maintenance. At the Galedffrwd scheme we would expect a 1,000rpm machine to be most suitable. For the dam scheme the turbine speed will be slower at around 600 to 750rpm. At this speed generators can be expensive so a belt drive may be required.

5.4 Control System

Modern control systems for commercial micro-hydro schemes are usually fully automatic, with a central computer (PLC[2]) communicating digitally with control inputs and outputs (e.g. meters, sensors and actuators). This would be the appropriate option for the Galedffrwd scheme but add cost for the smaller, dam scheme.

A low cost control system fro small scale hydro using induction generators has been developed by Sustainable Control Systems Ltd based in Herefordshire. This is a modular PCB design that has been used in the UK and world wide.

The EA may require a flow meter to be installed as a condition of granting the abstraction licence, to record abstracted flows. Flow meters are also useful for commissioning and monitoring purposes. They cost in the region of £2-3k (for a strap on, ultrasonic meter). They 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 pipeline system will most likely be Polyethylene (HPPE/MDPE plastic[3]). The material is robust, and modern pipes can be butt-welded to form a continuous length, potentially reducing the need for anchor blocks and also reducing the risk of joint failure. In certain circumstances, it can sometimes be backfilled with selective material dug out from the pipe trench (i.e. avoiding large or sharp rocks that could damage the pipe), particularly where there will be no significant vehicle loads on the pipe. This avoids the need for importing a graded backfill which can add 50-100% to the installation cost. Ground investigations will be required to ensure this is possible.

Prices per metre for PE are of the order of £22m for 315mm (PN6), and around £50/m for PN16/17 as would be used for the Galedffrwd scheme. However, being manufactured from plastic, the price is closely linked to the price of oil, and can fluctuate significantly.

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[2] PLC – Programmable Logic Controller

[3] 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.

5.5.1 *Pipe Head loss*

It should also be noted that, for peaty catchments (such as could be found in the catchments in question), over several years, deposits of peat can build up on the inside of the pipeline. This will gradually reduce the effective diameter of the pipe and increase head loss hence the need to consider pipe pigging (see below). How often this is required depends upon the characteristics of the catchment and the water and is hard to predict.

5.5.2 *Installation*

Pipeline installation costs of £50 per metre would be typical for this site, plus mobilisation costs. In terms of overall installation prices, an allowance of rock removal imported backfill for a length of 100m through rock or large boulders has been estimated for the Galedffrwd scheme as well as costs for passing the pipeline under the road bridge near the intake and potentially digging a new trench in the road and crossing the river near the powerhouse. The Dam scheme has complications of passing dams and removal of trees which would result in a similar cost per meter.

5.5.3 *Vents*

Allowance should be made for special breather valves at any high points along the route. These permit venting air in the pipe during pipe filling and operation and air admittance during draining down.

5.5.4 *Pigging*

Provision should be made for pigging (cleaning) the pipe regularly. This is usually done by flushing a foam swab (pig) down the pipe to remove slime and debris from the pipe walls. A chamber at the intake is required to launch the pig, and likewise some arrangement for removing it at the other end and discharging the effluent.

Dirty water from this operation should be captured and settled in a temporary pit before return to the watercourse, to avoid silt contamination or discolouration of the river.

6 Generated Energy Sales Prices

Power 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 is in the process of changing to a Feed in Tariff (FIT) system. The total price is made up from an export tariff and a generation tariff. The base energy price currently has a fixed floor price of £30/MWh, but this can be opted out of if a better price can be found from a supplier who will buy the energy. The generation tariff is an additional payment for every MW generated. Both elements are index linked. The table below summarises the rates that apply to eligible 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	199	30	229
15 to 100	178	30	208
100 to 2000	110	30	140
2000 to 5000	45	30	75

7 Power, Energy Output and Gross Income

Calculations are based on a Gilkes Turgo turbine for the Galedffrwd scheme and separate calculations based on a Crossflow and Propeller turbine for the Dam scheme. For the Crossflow calculations, the flow rate has been limited to 300l/s so that the generated power fits into the sub 15kW FIT band. A Crossflow sized for 400l/s could be used to make full use of the available water. The proposed Propeller turbines are only available in standard sizes. The size that best suits the head and flow of the Dam scheme would limit the flow to 165l/s.

These are estimations based on typical efficiencies and expected performance. The calculations assume:

- Abstraction of 80% of available flow above Q95 from January to March, and 60% of available flow above Q95 from April to December.
- Minimum flow of 10% of maximum turbine flow.
- 4% downtime
- Energy prices (under the new Feed in Tariff) assume an export floor price of £30/MWh

Results are as follows, with full details given in Appendix B.

Scheme & Turbine	Max Power (kW)	Average Annual Energy (MWh/yr)	FIT Price (£/MWh)	Gross Average Annual Income under FITS's
Dam-Propeller	12	37	229	£8,542
Dam-Crossflow	15	43	229	£9,932
Galedffrwd-Turgo	100	430	208	£89,535

For the Dam scheme, the Propeller turbine is able to utilise more of the available head so can produce more energy at lower flows. However the Crossflow can still generate more energy annually and produces a better return for the investment.

Initial calculations show that the Galedffrwd scheme is capable of producing around 136kW however the 50% higher FIT price/MWh for schemes sized below 100kW means that a 100kW scheme is the better economic option. Similarly with the Dam scheme, if a Crossflow is used it could potentially generate upto 20kW. This would increase the annual energy generated by 2 to 3MWh/yr but decrease the annual income by £300 to £400 and increase the initial project cost.

Energy outputs and income are average estimates only and can vary significantly (typically up to 20% depending upon gross rainfall and distribution/intensity throughout the year).

8 Grid Connection

Scottish Power (SP) have been contacted as part of this study. They have confirmed that no upgrades are required for the Dam scheme. Therefore the only charge should be for an SP engineer to witness the grid connection tests at a rate of around £500 + VAT.

For the Galedffrwd scheme a new ground mounted substation will be required at a cost of around £80,000. Below 200kW a pole mounted transformer is usually sufficient however SP state they can't install another pole mounted transformer in the area.

8.1.1 Earthing

Earthing (LV) will need to come from local grid via the main power cable or be built into the powerhouse foundations and/or along the cable trench as required.

8.1.2 Metering

A separate contract with a meter operator will be required for the installation and half-hourly recording of an export/import meter (COP5). This will require a phone connection, and if no mobile reception is present, then a BT landline will need to be installed. A BT landline is the best option if possible as it allows better and cheaper remote monitoring of the powerhouse.

Metering costs are currently around £600 per year, with a one off installation fee of a few hundred.

Although metering services can be sourced from any supplier, it is usually easier to use the local DNO, as this avoids having to manage the interface between them and the meter operator.

8.1.3 Standing charges

There will be an annual standing charge for the connection. The Transmission Network Use of System (TNUOS) charges are zero for this type of scheme, but the Distribution Use of System (DUOS) charge is currently 47p/kVA/month for an LV embedded generator (LLF class 909).

There will also be standard electricity supply charges for import to the powerhouse when the plant is not running for the control system and anti-condensation heaters etc.

9 Financial

9.1 Budget implementation costing

9.1.1 Dam Scheme

Initial cost estimates for the major parts of the scheme are outlined below:

Item	Cost
Turbine – Ecowave	£12,000
Turbine – Propeller (supplied and installed by Gilkes)	£17,500
Valves – MIV and intake chamber	£7,000
Generator and control system (SCS)	£5,000
Intake – design and construction	£25,000
Pipeline – DN500 PN6 PE at £50/m and installation estimated at £50/m	£12,000
Powerhouse – 4m x 5m design and construction	£30,000
Grid connection – metering, witness testing SP engineer, Dulas engineer and equipment hire	£1,600
Installation and commissioning	£10,000
Project management	£4,000
Consents – planning/abstraction applications	£4,000

This gives an estimation of overall capital outlay of £116,100 using a Propeller turbine and £110,600 using a Crossflow. Turbine costs are from supplier quotation and cost on previous jobs. Installation, commissioning and project management costs assume that some of this work will be done in house by Coetir Mynydd.

9.1.2 Galedffrwd Scheme

Initial cost estimates for the major parts of the scheme are outlined below:

Item	Cost
Turbine – Gilkes Turgo	£160,000
Valves – MIV and intake chamber	£10,000
Generator – induction	£18,000
Control system – design and materials	£35,000
Intake – design and construction	£30,000
Pipeline – materials and installation	£140,000
Powerhouse – design and construction	£40,000
Grid connection – new substation	£80,000
Installation and commissioning	£20,000
Project management	£10,000
Consents – planning/abstraction applications	£10,000
Total	**£553,000**

Turbine, generator and control costs are based on previous quotes and experience. The main unknown is in the cost of the civil installations; intake, pipeline and the powerhouse to a certain extent. Construction work of this extent and complexity would normally be tendered out with the detailed design (and preceding surveying, measuring up and ground investigations) being conducted by a separate consultant.

The powerhouse could also be built by a suitably supervised “builder” rather than a “civils contractor” to reduce costs.

9.2 Operational costs

9.2.1 Dam Scheme

Operational costs could be kept to a minimum by using engineers or suitably experienced members of Coetir Mynydd for standard maintenance and minor repairs. This will require training from an experienced hydro engineer which should be given to several people within the community group to ensure skills are not held by only one person. Rental/lease payments will not apply as all works are confined to the land owned by Coetir Mynydd.

There are a number of operating costs that apply to all micro-hydro schemes such as electricity connection related costs, insurance and maintenance related costs.

9.2.2 Galedffrwd Scheme

Operational costs will include:

- regular maintenance visits (greasing bearings, brushing screens, etc)
- annual inspection visits (full system checks)
- minor repairs

- business rates and taxes
- rent / leases with the landowner
- electricity use of system charges, import electricity and metering
- insurance

These we estimate would total approximately £10,000/year.

Maintenance costs can be drastically reduced if a competent local person can be employed in a caretaker role. An annual visit from an experienced hydro engineer should also be allowed for, and a provision of say £5k 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 valves can also reduce the maintenance costs, which can be £500 - £1000 per year for professional servicing.

Permanent lifting equipment (such as a gantry) will also need periodic inspections and tests by certified inspectors, with associated costs.

Business rates for micro-hydro schemes operated by 'single purpose' companies are currently being reviewed by the Valuations Office Agency and are expected to increase significantly compared to historic levels. A quotation can be applied for from the VOA. In the mean time, a figure of £2k to £5k should be budgeted. Other taxes may apply. Debt finance repayments have not been included.

Insurance can be limited to plant and machinery repair, or also include 'loss of generation' due to operating faults. Cover should also include public liability and employer liability if appropriate. Clearly, comprehensive insurance cover to this extent is normally reserved for larger schemes but will probably apply to the Galedffrwd scheme. Adding cover to an existing business or estate policy may be the cheapest way to insure a micro-hydro scheme.

9.3 Lifetime

Hydro schemes generally have a design life of 30-40 years, but with a major overhaul budgeted for after 10 to 15 years of operational service. 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. The pipeline will need periodic cleaning (pigging) especially if there is significant peat build up on the internal walls. The pipeline should last at least the life of the scheme provided it has been properly specified and installed (this includes anchoring, venting and backfilling requirements). In terms of cost, there is usually a gradual replacement of parts over the years as components wear out or fail, plus some medium scale work during any major overhaul as discussed above.

It should be noted that the cost of engineering time (and travel time) 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.

10 Implementation

It is envisioned that much of this work for the Dam scheme will be done in house by Coetir Mynydd to save on costs. For a small scale project such as the Dam scheme, much of the standard processes would be excessive or unnecessary such as appointment of a project manager or Construction Design and Management (CDM) co-ordinator. However taking note of standard industry practice and adapting this for implementation of the Dam scheme may result in smoother running of the project and help to keep within time and budget.

The Galedffrwd scheme development would follow a more typical implementation process as outlined below:

10.1 Project program

Hydro schemes are usually built in several stages as follows:

- Feasibility study and outline design
- Consents (planning, abstraction, grid connection)
- Detailed design
- Issue of tender(s)
- Construction
- Commissioning (including performance testing, de-snagging etc)
- 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 3-6 months for design and an actual construction period of 9-12 months, depending on supplier availability and seasonal construction issues. For turnkey installations some of the design work may run concurrently with the construction.

10.2 Management and Contracts

If the scheme is to be a turn-key project 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, powerhouse build and electro-mechanical installation and commissioning. In all cases, a clear management and responsibility structure is key to building a successful scheme.

Standard construction contracts, such as those produced by NEC, are suitable for this size of scheme, with Minor Works contracts sufficient for some or all of the individual items.

10.3 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 a few thousand pounds. Early appointment can help to design-out potential problems before construction starts, and can result in a better all round scheme.

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[4] www.hse.gov.uk/construction/cdm.htm

11 Conclusions

All options outlined in this report are potentially viable. The dam options have the advantage of the entire scheme being located on Coetir Mynydd owned land. This would likely increase the sense of ownership and responsibility for the community and would mean all profit from the scheme would go to the community group. However a dam scheme alone would not be making full use of the potential power in the Afon Galedffrwd.

The Galedffrwd scheme needs further technical development work, mainly to investigate pipe route options and land owner agreements. Based on the initial analysis there is potential for a viable scheme. It was initially assumed that an external investor would be required for this development, which may be the case. However there are other community groups in north Wales that are investigating funding schemes of this size and cost. Even if an external investor is required, the most logical location for the power house is on Coetir Mynydd land, as stated in this report. It is typical in hydro schemes for landowners with the powerhouse to receive a percentage of profit from generation. Therefore this would generate money for the community but not require the long term maintenance by Coetir Mynydd.

If the Galedffrwd scheme goes ahead there may still be an option of a hydro scheme from the dam using a Propeller turbine. The Average Daily Flow (ADF) is estimated at just over 400l/s at the dam but the Galedffrwd scheme would run on a maximum flow of around 150l/s. The most suitable Propeller size for the Dam scheme would use upto 165l/s so there may be potential to run both. This option would need further investigation and consultation with the EA. If this could work, one option would be to install the Galedffrwd scheme (using external investors or otherwise) and then use the existing measurement equipment at the dam to record how the flow has changed. Profit from having the powerhouse on Coetir Mynydd land could then be used to help fund a Propeller scheme using the dam.

12 Recommendations

Recommendations for follow up:

- Decide which option to investigate further
- Tie down EA and Gwynedd Council requirements and carryout surveys as required
- Site visit with civil contractors (both high and low end / local) to discuss outline designs and options
- Prepare planning and abstraction applications