RHONDDA CYNON TAF COUNTY BOROUGH COUNCIL
CORPORATE ESTATES

RHONDDA CYNON TAF

APPENDIX ‘A’

Hydro Electric Viability ‘Overview Report’

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Executive Summary

In 2017, the Welsh Government set a target to all Public Bodies across Wales to achieve carbon neutral status by 2030. In contribution to this aim, the Welsh Government has committed a target to generate 1 Gigawatt of locally owned renewable electricity and heat capacity in Wales by 2030.

Rhondda Cynon Taf County Borough Council recognises that it has an important role to play in supporting the increased scale up on renewable energy generation across the County Borough. As such, the Council are making every effort to increase its portfolio of renewable energy generation in contribution towards reduced energy consumption, carbon emissions, and the Welsh Government's 2030 Net Zero target.

In 2012, Rhondda Cynon Taf County Borough Council engaged with The Green Valleys Hydro (TGV) to identify and assess potential sites across Rhondda Cynon Taf for the development of small-scale hydroelectric power schemes. In total, the feasibility study assessed 67 potentially viable hydro scheme opportunities, proposing 30 of these sites for consideration and further assessment.

The 30 viable hydroelectric scheme sites are presented in depth throughout this report, accompanied by site description, power analysis and indicative costs. Each of these 30 schemes have been recommended for a detailed feasibility study in which more accurate data can be gathered on site. All the sites that have been recommended for more detailed feasibility have payback periods of less than 9 years. The hydropower resource generated across these schemes would support a range of project sizes, with private wire potential to Council buildings, providing community and Council benefit.

With the declaration of a Climate Emergency by the Welsh Government and the target to decarbonise the Council's estate to Net Zero by 2030, there is now an increased need to revisit the assessment of the proposed schemes and conduct further feasibility, on the schemes most favourable, in aim of increasing the Council's renewable energy generation.

It is the Council's ambition to maximise the roll out of renewable generation across the County Borough, bringing benefit to community groups and residents. Following assessment of the sites set out within this report and the progression of the most feasible sites to in depth feasibility, the remainder of the schemes can be adopted by the community for their assessment and implementation where suitable.

Methodology

The topographic and flow characteristics of all major streams within the area of interest have been analyse against their payback periods. For planning purposes, it is considered that where required, three phase supply is available reasonably close to the required connection point. The costs of bringing a three-phase supply over a large distance into rural areas can often be prohibitive. In urban areas a three-phase supply is more readily available.

A Viability Report has been created for the sites with most potential which includes an estimate of the probable flow and head for the scheme, the likely energy generation capacity, and an estimate of construction costs based on our experience of similar sites.

The construction cost of each site detailed in this report has been estimated by TGV Hydro based on similar schemes. It includes all equipment and construction costs, the grid connection, and the commissioning of the schemes. The price also includes estimated external costs of ecological surveys that may be necessary for obtaining the permissions and licences and the cost of transformer upgrades that Western Power may require. The costs detailed in the appendices have VAT included at a rate of 20%. Should a project go ahead at a domestic scale then VAT would be charged at 5%.

This report outlines a first indication of each site's potential. To better determine a sites potential a full Feasibility would be required. This would include a site visit and research into factors which may affect the ecological impact, geology, construction methodology and costs which were not apparent from our initial desk-based exercise.

The next process is for the Client to review the information to identify those sites which they may consider taking forward for further investigation.

Areas Covered

The study focusses on the area of the Rhondda Cynon Taff with the reports presented in localised geographic areas. These are:

- North West Area: Hirwaun and surrounding area
- North East Area: Foothills of the Brecon Beacons and surrounding area
- Central West Area: Treherbert, Treorcy , Tonypandy and surrounding area
- Central East Area: St Gwynno Forest, Abercynon and surrounding area
- South West Area: Tonyrefail and surrounding area
- South East Area: Pontypridd and surrounding area

The sites examined from each search area are set out below.

Key for All Maps:

- Viable hydro sites catchments are coloured blue.
- Each schemes pipeline is coloured green.
- Pink line denotes the RCT area boundary

Each of the 30 most promising schemes have a site map included in the viability report summary found in the appendices.

Summary of Findings

Models have been used to predict the flow and power production potential at each site to estimate payback intervals. The longest expected payback interval for each system is presented below. Similarly, the construction cost estimations presented are for the greatest expected construction cost at the time of the report in 2012 which includes a 10% contingency but does not include VAT. Full details of the range of expected costs and benefits for the most promising 30 sites are outlined in each individual report in the appendix.

Table 1 summarises the findings from the 30 most viable hydro sites in the area. The smallest viable site identified in this exercise has the potential to generate in the region of £12,000 p.a. whilst the largest could potentially generate in excess of £103,000 p.a. Construction costs for developing each site range from £66,000 to £622,000. The estimated 'gross payback' of each site varies from less than 4 years to slightly over 9 years.

Table 1 The most viable hydroelectric schemes in RCT area.

SITE NAME	TGV Ref	PEAK POWER (kW)	ANNUAL kWh	REVENUE P.A. (£)*	APPROX CONSTRUCTION COST (£)**	APPROX PAYBACK YRS***
Afon Rhondda Fach	TGV12/003AA	83.2	502,061	81,117	622,221	6.9
Cwmaman	TGV12/003AC	26.3	99,435	20,128	120,018	5.4
Coed Cae	TGV12/003AE	22.9	90,011	18,211	98,432	4.9
Cwmpennar	TGV12/003AI	14.0	54,170	12,072	66,261	4.11
Ton Pentre	TGV12/0063AJ	30.9	121,606	24,616	123,777	4.6
Pistyll-goleu	TGV12/003AL	48.4	198,150	40,111	349,508	7.7
Ynysybwl 1	TGV12/003AP	30.0	139,112	28,160	162,710	5.2
Nant Cae-dudwg	TGV12/003AT	47.6	190,398	38,542	236,212	5.5
Clydach Vale	TGV12/003AU	26.7	103,793	21,011	105,760	4.6
Trehafod	TGV12/003BC	16.4	70,462	15,361	69,170	4.2
Rhiw-yr-uchain	TGV12/003BD	13.9	56,327	12,553	79,230	5.7
Thomastown	TGV12/003BG	22.4	88,794	17,974	116,330	5.9
Ty-draw	TGV12/003BH	13.4	54,213	12,082	112,639	8.1
Graig	TGV12/003BI	30.0	132,637	26,849	231,452	7.6
Rhydyfelin	TGV12/003BJ	24.3	95,818	19,396	105,424	4.10
Ty Rhiw	TGV12/003BQ	14.0	58,422	13,020	102,364	6.11
Nant-moel Reservoir	TGV12/003F	23.6	83,199	16,842	145,195	7.6
Llwydcoed	TGV12/003G	20.6	74,279	15,036	130,327	7.6
Pont Walby	TGV12/003I	50.5	174,778	35,380	243,776	6.1
Rhigos	TGV12/003J	13.7	55,805	12,437	133,165	9.2

SITE NAME	TGV Ref	PEAK POWER (kW)	ANNUAL kWh	REVENUE P.A. (£)*	APPROX CONSTRUCTION COST (£)**	APPROX PAYBACK YRS***
Mynydd Cefn y Gyngon	TGV12/003K	25.5	100,381	20,320	100,685	4.5
Llwyn-helyg	TGV12/003L	14.8	56,859	12,672	79,111	5.6
Blaenrhondda 1	TGV12/003Q	99.4	513,409	103,929	382,119	3.4
Blaenrhondda 2	TGV12/003R	55.2	215,887	43,702	183,170	3.9
Bleanrhondda 3	TGV12/003S	25.8	100,203	20,284	92,605	4.1
Bleanrhondda 4	TGV12/003T	29.7	123,510	25,002	102,786	3.9
Cwm Selsig	TGV12/003U	56.0	217,760	44,081	214,626	4.4
Tynewydd	TGV12/003W	29.8	121,401	24,575	128,018	4.8
Cwm Saerbren	TGV12/003X	24.5	96,627	19,560	100,805	4.7
Cwmparc	TGV12/003Z	54.4	257,170	52,059	348,977	5.11

*Before tax and other deductions
**Costs do not include VAT
*** Payback calculation includes an annual incremental increase in the price for electricity export, the FIT rate and domestic bill savings.

Revenue Rates and Technology Comparisons

The estimated annual revenue for a scheme will not be the same as the estimated profit. The following are typical considerations that may have an impact on profit margins, and these have not been included in table 1 above:

- General expenses such as maintenance, equipment replacement and insurance.
- Tax liabilities, interest payments on loans.
- Some of these sites may involve using multiple landowners to enable grid connection. These subsidiary landowners may require a payment before granting the required Deed of Easement.
- Potential planning obligations through a Section 106 agreement to ensure that some of the scheme revenue is diverted into ecological improvements.

The income calculations assume that the schemes will be eligible for the Feed-in Tariff from the UK Government. This support is paid to renewable energy producers in various amounts according to type of technology and the power produced. The core FITS tariff is based on the total number of kWh's that are generated. In addition, all exported electricity will benefit from an addition export fee. Many renewable energy producers look to maximise the use of their generated electricity on site to offset electricity that they use to buy in. Any excess electricity is then exported to the national grid.

The FITS generation tariff varies for each technology and with the size of scheme. The rates are index linked against the retail price index (increase applied each April). The unit rate that excess electricity is sold can be negotiated with the electricity companies. FITS guarantees a minimum rate (£0.031 per kWh at the time of reporting) the electricity companies must pay. This again is index linked rising every April.

Currently from the moment of commissioning FITS payments are guaranteed for 20 years for Hydropower generation. The overall FITS mechanism is regularly reviewed and the terms and conditions for new schemes could change.

The reliable availability of water and the 24 hour a day generation of a hydroelectric generator means that the energy output and therefore financial return of the hydroelectric system are higher than other technologies. Table 3 compares 11kw installations for different technologies. These figures reflect the fact that hydro power can be generated 24 hours a day (unlike PV) and that although there are seasonal fluctuations in flow there is a more consistent generating output than from wind.

Table 2 FITS rates for different technologies.

Technology	Scale	FIT Rate/KWH
Hydro	< 15kW	20.9p*
Hydro	15-100kW	18.7p*
Hydro	100KW-2 MW	11.0p*
Wind	1.5-15kW	28.0p*
Wind	15-100kW	25.3p*
Solar PV	4-10 kW	37.8p**
Solar PV	10-100 kW	32.9p**

*Rates to be reviewed in April 2012 for all new schemes
**For schemes commissioned before 12th December 2011.

Table 3 Comparison of returns for 11kW systems of different technologies taking into account seasonal variations and daily fluctuations.

Technology	System size	FIT Rate/KWH	Annual Return
Wind (Avg. 7m/s)	11kW	28.0p	£6,995
Hydro	11kW	20.9p	£12,055
Solar PV	11kW	32.9p	£2,895

IMPORTANT NOTE:

The FiT rates referred to herein, and which were in force at the time of the original report, are no longer applicable.

The FiT scheme, as referred to in the original report, was discontinued by the UK Government since 2019.

A replacement scheme has now been introduced in 2022.

The new scheme goes under the title of 'SMART Export Guarantee'.

It should also be noted that the rates in the new scheme will vary considerably from those used to assess finances in the original study, and this will be fully considered in any subsequent feasibility studies.

Sites Recommended for Full Feasibility Study

There is significant potential for the development of micro hydro installations across the RCT area with 30 sites recommended for further investigations. In order for the 30 recommended schemes to be accurately costed and assessed a further detailed onsite feasibility study is essential.

Taking the Projects Forward

A typical hydro project should take about 12 -18 months from conception to implementation. The main stages will be the Feasibility Study, Design and Permission, and Construction.

(1) Feasibility Report

Any feasibility study commissioned for a prospective installation would include details of:

- *Geographical analysis* – discussing the catchment area of the proposed installation as well as the particulars of the local geography and topography on site. This analysis should enable the description of the Abstraction regime required for the proposed system design.
- *Civil works* – A description of any required preparation of site, the intake structure, the forebay tank, turbine house and any discharge infrastructure needed.
- *Turbine and generating equipment* – A description of the generating equipment explaining its suitability to the proposed installation
- *Grid connection* - details of the proposed grid connection location and technique demonstrating that the connection will be sufficient to deal with the generation capabilities of the proposed system.
- *Energy resource and projected income* - Although it is unrealistic to expect the feasibility study to accurately predict rainfall levels in the coming years, an educated estimate of annual income based on catchment area analysis and system design.
- *Full detailed costing of the proposed installation* - This should include parts and labour as well as the costs of any permission required for installation.
- *Other features* – the feasibility study should highlight any anomalous features such as listed buildings, Nature reserves or SSSi's including preserved trees that may possibly be affected by any installation. The Feasibility Study should also highlight any potential planning or environmental issues that may stand in the way of a proposed installation.

(2) Design and Permissions

Assuming that the feasibility study has highlighted no barriers standing in the way of the proposed installation it will be necessary to approach the local planning authority and the Natural Resources Wales for formal permissions for the installation.

i. Natural Resources Wales (NRW)

An abstraction licence is needed for permission to remove the water from the river or stream. Although with hydroelectric the water is going to be returned to the same stream a little further down, it will still leave a section of river or stream with less water than it had before, known as the *depleted reach*. The reduced amount of water in the depleted reach can affect organisms including migratory fish, endangered indigenous crayfish, and mammals such as otters as well a range of lower plant species (mosses and bryophytes) that depend on the increased relative humidity of the habitat to survive and thrive.

The abstraction licence gives permission to abstract water, to create a weir or dam and to discharge the water back into the waterway. The basic cost of the application is around £200 but there may be other associated costs including the advertising of the application and surveys as required by NRW . It is important to call NRW and discuss the proposal even before the feasibility study takes place in order to highlight any potential pitfalls or barriers in the way of development as soon as possible. The abstraction licence application is a complicated process with many required fields of data.

ii. Local Planning Authority

The local planning authority will have several key purposes in mind when considering any application, namely:

- The appearance of the scheme, they will consider whether it is sympathetic to the local vernacular and landscape
- Pollution with hydro electrics, any noise pollution resulting from an installation.
- Disturbance to the local area during the construction of the installation, to residents and disruption to the local traffic
- Preservation of any structures of historical importance in the area such as listed buildings or other archaeological features.

Conclusion

As an area of significant hydro potential, RCT has a unique opportunity to develop a substantial number of micro-hydro generation schemes. The initial studies have indicated that are over 30 viable schemes that could be developed to both reduce carbon emissions and earn a worthwhile return on investment by utilising the 20-year guaranteed and index linked Feed-in Tariffs. Any of the 30 recommended sites will require full feasibility reports completed to be considered for progressing to the next stage of the project.

Appendix

Site Identification Overview

Table 4 North West: Hirwaun and surrounding area

SITE NAME	Map Ref.	Peak Power (kW)	Intake Grid Reference	Site Description
Pontneddfechan	H	7.2	SN 9101 0744	Pipe is trenched through open fields and includes one major road crossing although through an existing culvert. Turbine house is outside of the client's identified area. Grid connection is assumed to be available in Pontneddfechan at an approximate distance of 50m from the turbine house.
Pont Walby	I	50.5	SN 9041 0552	Pipe is trenched adjacent to wooded corridor. Site is based on the border of the client's identified area.
Rhigos	J	13.7	SN 9254 0410	Pipe follows contour before dropping to turbine house, potential flow anomalies surrounding local disused mines.
Mynydd Cefn y Gyngon	K	25.5	SN 9631 0290	Pipe is trenched across open fields, Grid connection is available within 30m at a local property
Llwyn-helyg	L	14.8	SN 9778 0203	Pipeline is trenched alongside existing forestry track., Grid connect is available at local farm and camping
Llwyn-helyg 2	M	1.8	SN 9862 0210	Pipeline is trenched alongside existing forestry track., Grid connect is available at local farm
Llywn-helyg 3	N	10.3	SN 9934 0207	Pipeline is trenched through agricultural land, Grid connect is available at , or near, local school.
Blaenrhondda 1	Q	99.4	SN 9197 0170	Difficult terrain including rocky outcrops and coniferous plantation. Lower stages could utilise forestry tracks. Significant export potential.
Blaenrhondda 2	R	55.2	SS 9180 9970	Difficult penstock route through coniferous plantation. Local domestic connections available.
Bleanrhondda 3	S	25.8	SS 9154 9924	Difficult penstock route through coniferous plantation. Local domestic connections available.
Bleanrhondda 4	T	29.7	SS 9084 9879	Penstock route through coniferous plantation and agricultural land. Local domestic connections available.
Tynewydd	W	29.8	SS 9366 9990	Penstock through agricultural fields. Utilise existing culvert for export in Tynewydd.
Cwmaman	AC	26.3	SS 98331 9956	Pipe trenched in steep sided valley following forestry tracks, export at local property.
Rhos-gwawr	AD	6.9	SO 0061 0032	Small catchment and only medium head, export available at multiple local properties.
Afon Rhondda Fach	AA	83.2	SN 9505 0158	Pipeline starts at outflow from existing reservoir, detailed reservoir flow data required and status of use. Pipe runs trackside through coniferous plantation. Maximum power will likely be limited to compensation flows of reservoir.

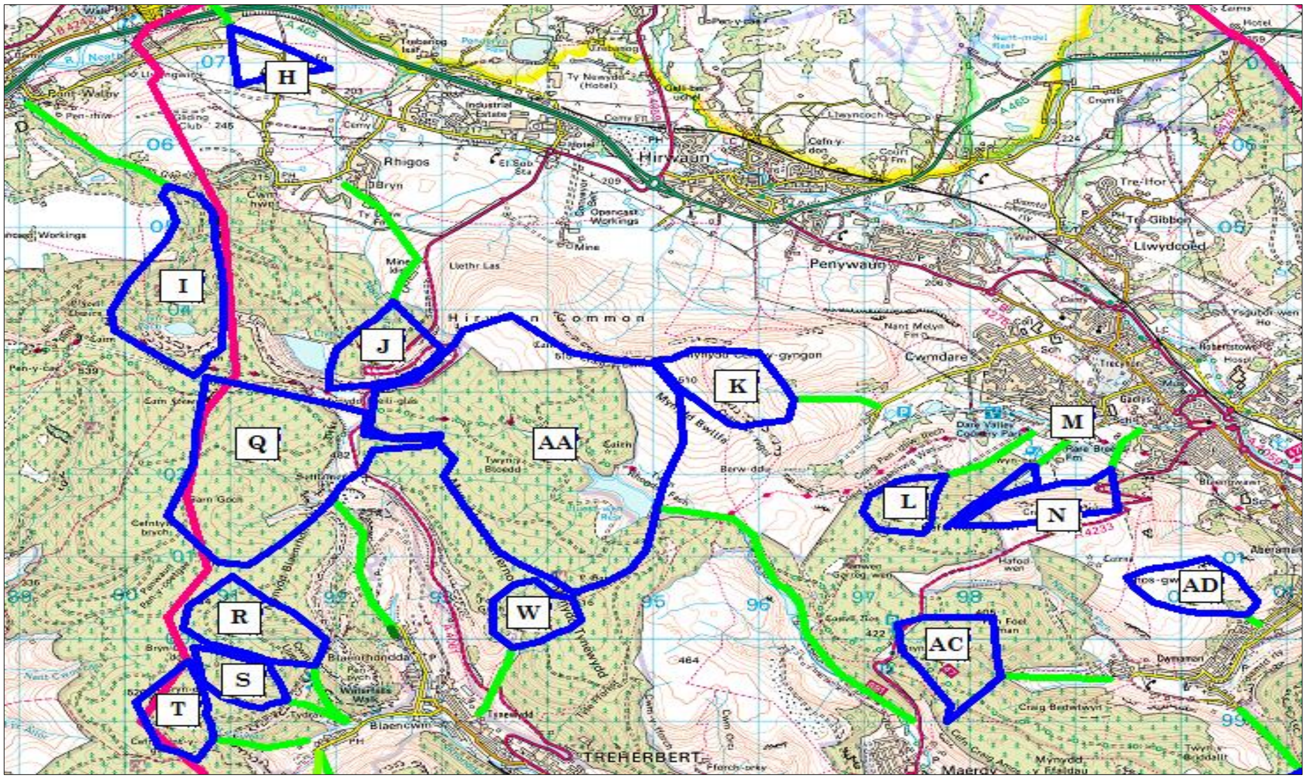


Figure 1 Location of potential micro hydro sites in North West RCT

Table 5 North East: Foothills of the Brecon Beacons and surrounding area

SITE NAME	Map Ref.	Peak Power (kW)	Intake Grid Reference	Site Description
Garwnant	A	30.0	SN 9951 1327	Pipe trenched along forestry track. This site has already been progressed by the landowner to seek an abstraction licence and planning permission.
Penderyn	C	5.5	SN 9585 0859	Pipe trenched through open fields. Grid connection assumed to be available at Penderyn distillery adjacent to the turbine house.
Gelli-ben-uchel	D	12.9	SN 9589 0752	Pipe is trenched through open fields and deciduous woodland; grid connect available approximately 80m away at local property.
Nant Hir Tributary	E	4.7	SN 9739 0900	Pipe is trenched through open fields of a moderate slope and some deciduous woodland. Export is available through a property approximately 50m away
Nant-moel Reservoir	F	23.6	SN 9797 0705	Proposal to use excess water from reservoir. Utilise existing culvert with penstock through agricultural land. (NEW IMAGE NEEDED)
Llwydcoed	G	20.6	SN 9941 0629	Small catchment, pipe trenched across pasture on moderate slope to export at a local property.
Ffrwd Uchaf	IB	9.6	SO 0140 0883	Pipe surface laid through coniferous plantation and trenched in open field. Grid connection is available approximately 60m away

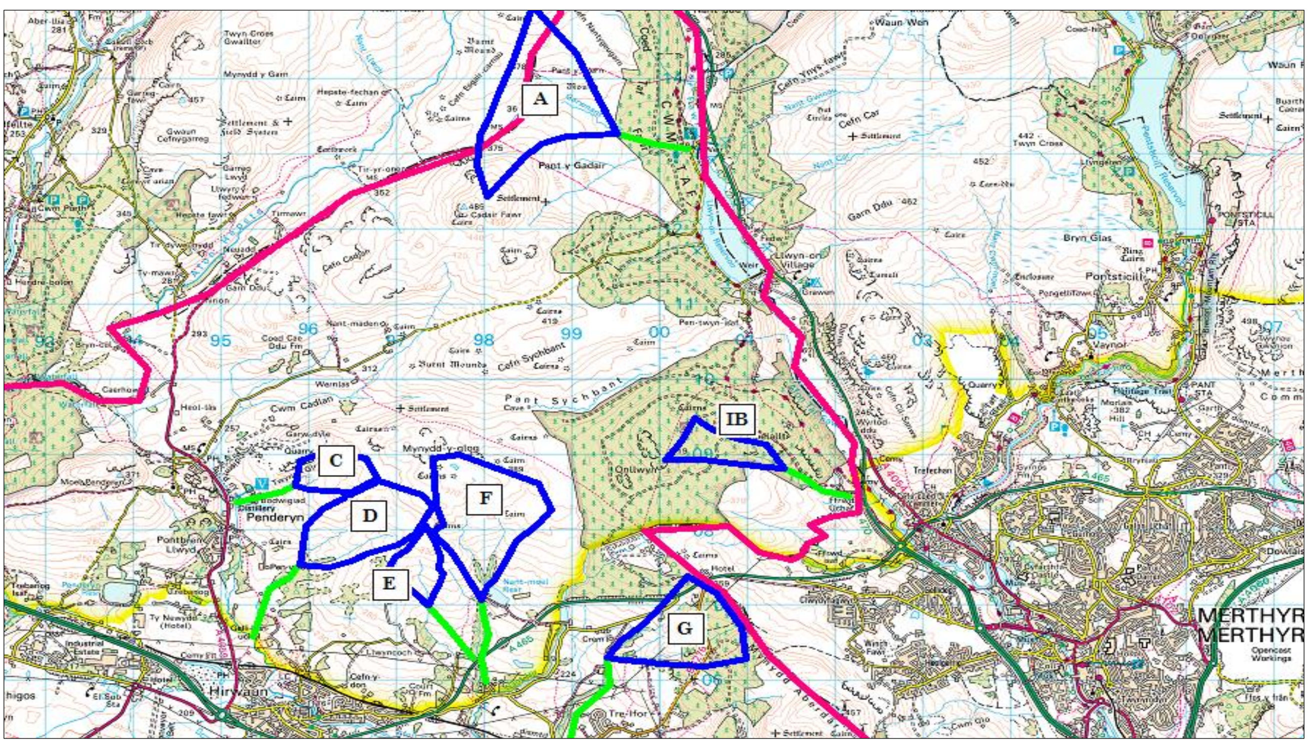


Figure 2 Location of potential micro hydro sites in North East RCT

Table 6 Central West: Treherbert, Treochy, Tonypandy and surrounding area

SITE NAME	Map Ref.	Peak Power (kW)	Intake Grid Reference	Site Description
Cwm Selsig	U	56.0	SS 9132 9774	Mixture of plantation and agricultural fields for penstock. Multiple export options in Blaen cwm. 3-phase connection would be preferable.
Blaen cwm	V	8.2	SS 9198 9815	Steep penstock laid through agricultural fields. Multiple export possibilities available through single phase connection.
Cwm Saerbren	X	24.5	SS 9325 9784	Pipe surface through coniferous plantation exclusively. Multiple Grid connections available in Treherbert.
Tyle Coch	Y	8.0	SS 9448 9668	Small catchment, high head. Pipe trenched in and alongside coniferous plantation with grid connection available at the local school.
Cwmparc	Z	54.4	SS 9382 9576	Pipe laid through agricultural fields with multiple connection options throughout Cwmparc.
Ton Pentre	AJ	30.9	SS 9543 9500	Entire pipe run trenched in open fields, follows contour before dropping to turbine house. Multiple export options.
Ystrad	AK	12.7	SS 9860 9611	Small catchment high head. Pipe run is trenched alongside deciduous woodland corridor. Multiple export options.
Clydach Vale	AU	26.7	SS 9601 9307	Medium catchment with high head, steep sided valley poses access issues for excavation machinery. Would be sited upstream of existing hydro scheme.
Penrhys Isaf	AV	7.2	ST 0115 9333	Small catchment and high head allows for small diameter pipe available in rolls. Trenched through agricultural fields and multiple export options.
Penygraig 1	AY	12.8	SS 9880 9163	Small catchment on moderate slope, trenched through agricultural land. Export available through local school.
Penygraig 2	AZ	4.3	SS 9935 9086	Small catchment with pipe trenched on moderate slope through agricultural land. Multiple export options.
Penrhiwfer	BA	10.4	SS 9976 9018	Moderate catchment and head. Penstock through agricultural fields. Export at local property
Trehafod	BB	9.1	ST 0339 9056	Small catchment high head, pipe trenched in open field on moderate slope, export option available at local heritage centre.

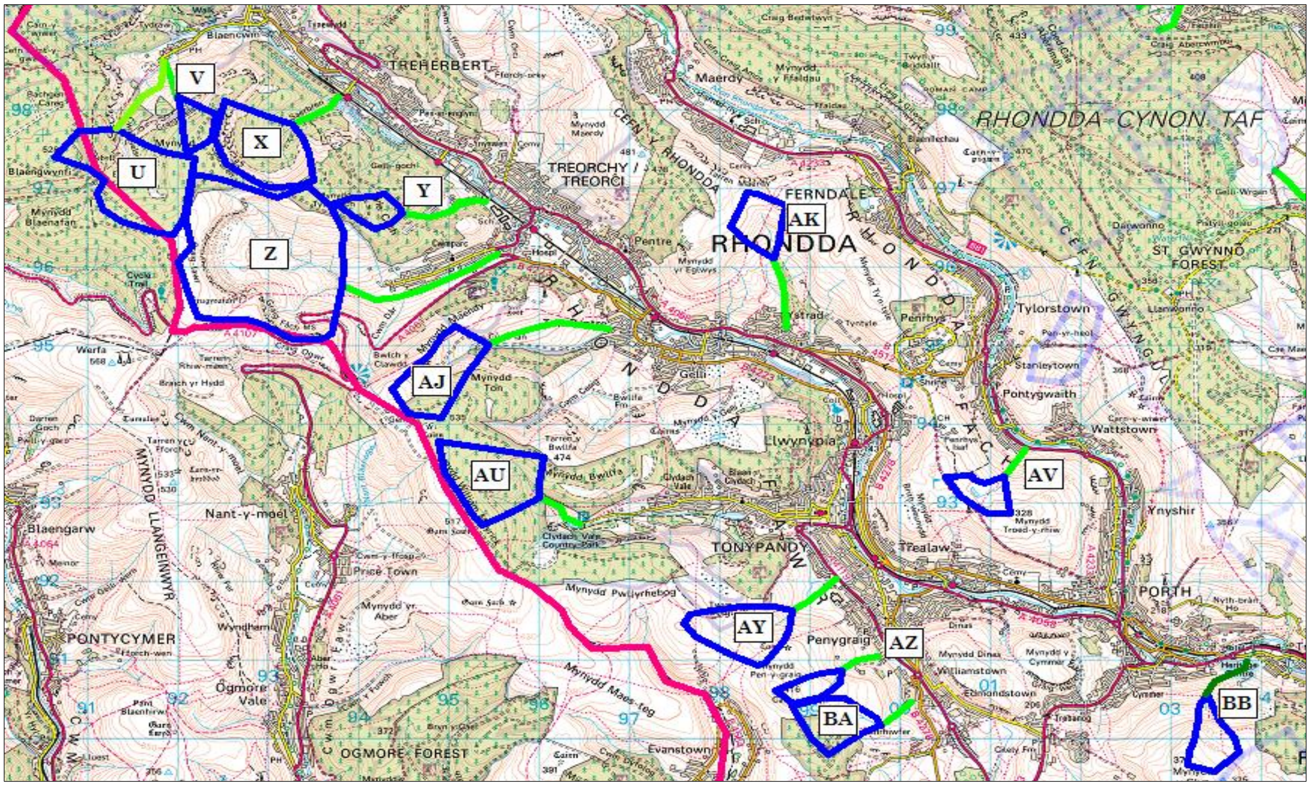


Figure 3 Location of potential micro hydro sites in Central West RCT

Table 7 Central East: St Gwynno Forest, Abercynon and surrounding area.

SITE NAME	Map Ref.	Peak Power (kW)	Intake Grid Reference	Site Description
Ffynnon-y-Gog	O	8.3	SO 0357 0220	Small catchment high head, pipe trenched across open field on moderate slope. Grid connection through adjacent property within 50m.
Coed Cae	AE	22.9	ST 0113 9841	Steep sided valley with a mix of coniferous plantation and agricultural land. Multiple export connection options.
Abercwmboi 1	AF	3.0	ST 0249 9938	Small and narrow catchment. Penstock through coniferous plantation. Multiple export options in Abercwmboi.
Abercwmboi 2	AG	3.3	ST 0263 9931	Small and narrow catchment. Penstock through coniferous plantation. Multiple export options in Abercwmboi.
Abercwmboi 3	AH	8.6	ST 0287 9902	Small catchment high head, pipe trenched in open field on moderate slope.
Cwmpennar	AI	14.0	SO 0541 0020	Pipe trenched through open field and surface laid through deciduous woodland. Will need to avoid cemetery. Export at local property.
Pistyll-goleu	AL	48.4	ST 0299 9663	Pipe trenched through coniferous forestry with potential to utilise existing reservoir structures. Flow data verification needed if reservoir is still active.
Gelli Wrgan	AM	12.5	ST 0348 9759	Pipe surface laid through forestry and trenched across pasture. Export at nearby property approximately 80m.
Gelli Wrgan 2	AN	11.2	ST 0414 9723	Pipe length trenched across pasture, export at adjacent property approximately 50m.
Ysysboeth	AO	10.9	ST 0695 9581	Small catchment high head. Pipe surface laid through forestry, export at local property.
Ynysybwl 1	AP	30.0	ST 0450 9440	Possibilities for penstock either through fields or woodland corridor. Multiple connection options.
Ynsysbwl 2	AQ	5.1	ST 0514 9387	Small catchment and high head allows for small diameter pipe available in rolls. Trenched penstock through fields.
Carnetown	AR	1.8	ST 0740 9415	Small catchment with a surface laid penstock through coniferous plantation.
Llys Nant	AS	14.0	ST 0568 9310	Medium catchment and moderate head. Pipe trenched across pasture. Export at adjacent property.
Nant Cae-dudwg	AT	47.6	ST 1088 9336	Moderate catchment and head. Pipe trenched along contour of valley before rapid fall through pasture. Export at local property
Wattstown	AW	8.6	ST 0181 9454	Medium catchment with a short pipe run trenched across pasture. Multiple options for connection to the grid.
Ynyshir	AX	2.5	ST 0289 9317	A small scheme with penstock trenched through pasture. Multiple export options.

Trehafod	BC	16.4	ST 0421 9201	Small catchment with high head. A mixture of over-ground through woodland and trenched through pasture for the penstock route. Grid connection at local property.
Rhiw-yr-uchain	BD	13.9	ST 0553 9180	Small catchment with high head. A mixture of over-ground through woodland and trenched through pasture for the penstock route. Grid connection at local property.

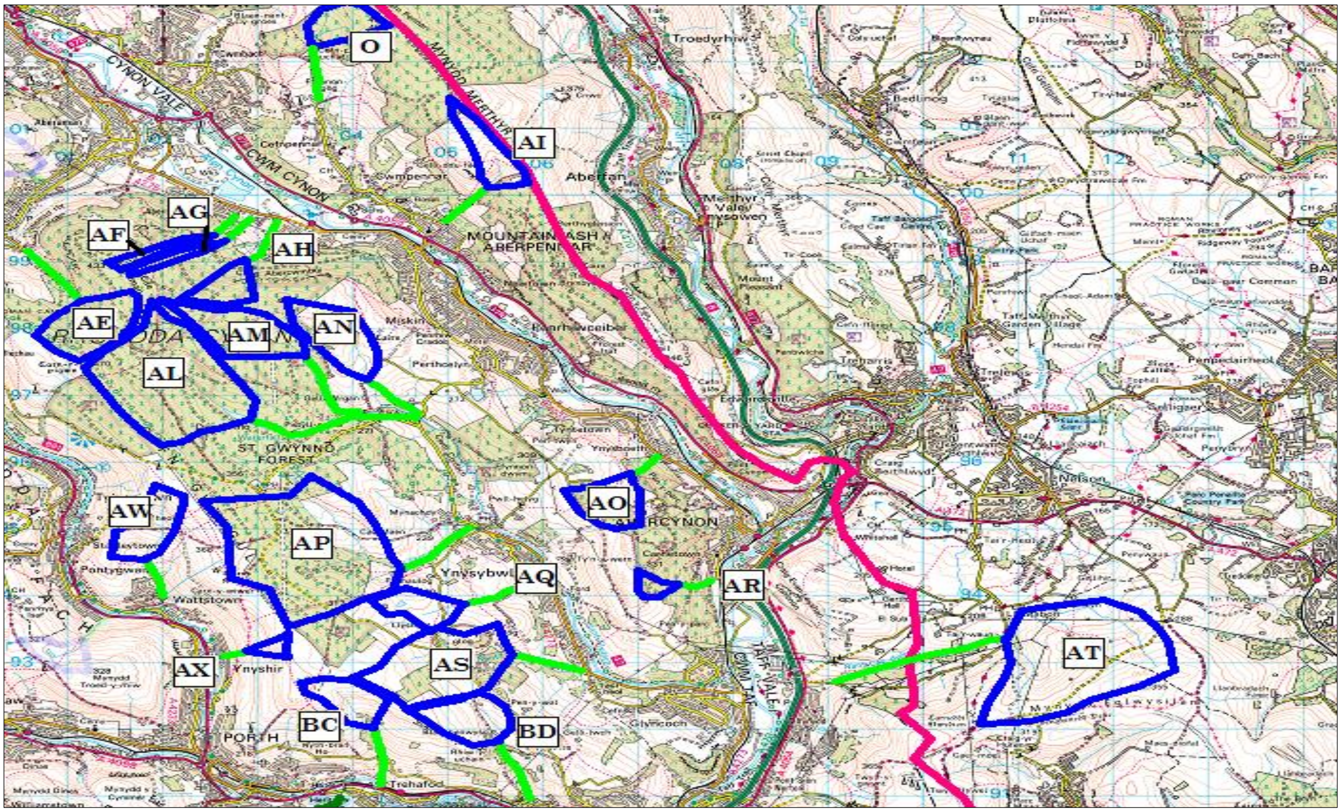


Figure 4 Location of potential micro hydro sites in Central East RCT

Table 8 South West: Tonyrefail and surrounding area

SITE NAME	Map Ref.	Peak Power (kW)	Intake Grid Reference	Site Description
Tynewydd	BE	2.4	SS 9781 8712	Small catchment with a long penstock. All works through pasture land with assumed export 100m from turbine location.
Pen-yr-heol	BF	2.3	ST 9771 8664	Small catchment with a long penstock. All works through pasture land with assumed export 100m from turbine location. (Export could be the same property as scheme BE).
Thomastown	BG	22.4	SS 9936 8654	Medium catchment with high head. Penstock trenched across pasture with multiple export options through adjacent properties.
Llantrisant Forest	BL	2.6	ST 0175 8475	Small catchment and high head but limited availability for export to the Grid. Penstock would be surface laid in forestry.
Mynydd Garthmaetwg	BM	1.5	ST 0232 8441	Small catchment and high head but no suitable export point, pipe would be surface laid in forestry.
Craig-melyn	BN	3.3	ST 0186 8338	Small catchment and high head, pipe surface laid in forestry although possibility of part trenching through pasture is available. Export through local property.
Garth	BO	3.6	ST 0237 8305	Small catchment with high head. Penstock trenched through agricultural fields. Export at local property.

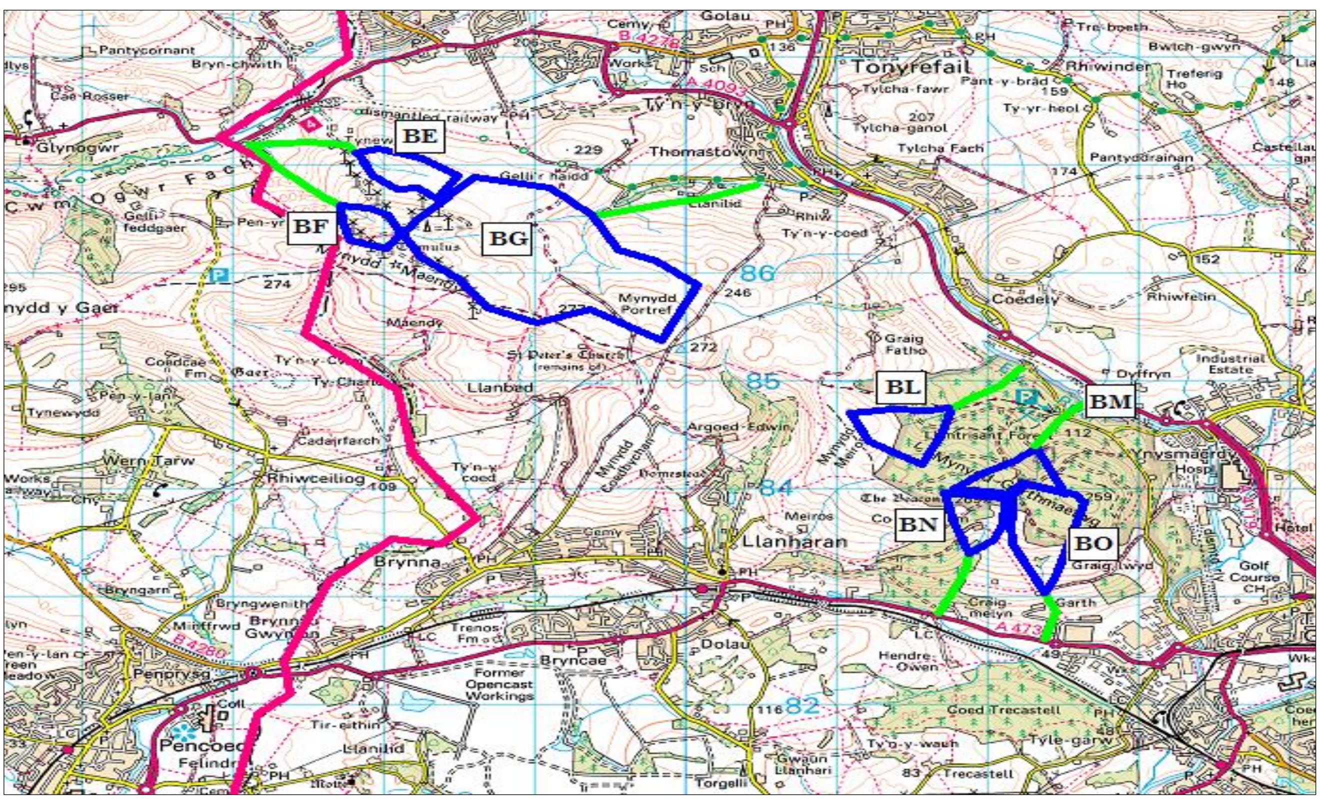


Figure 5 Location of potential micro hydro sites in South West RCT

Table 9 South East: Pontypridd and surrounding area

SITE NAME	Map Ref.	Peak Power (kW)	Intake Grid Reference	Site Description
Ty-draw	BH	13.4	ST 0465 8925	Medium catchment and high head. One unclassified road crossing with penstock trenched through pasture. 1 of 2 potential systems on the same waterway.
Graig	BI	30.0	ST 0582 8864	Large catchment with medium head. 2nd potential system on watercourse (BH). Most works assumed within wooded corridor.
Rhydyfelin	BJ	24.3	ST 1032 8906	Medium catchment with high head. Penstock would be trenched in open field adjacent to wooded corridor. Multiple export options exist.
Gelynog	BK	8.3	ST 0524 8731	Small catchment with a long pipe trenched across pasture and adjacent to wooded corridor. Export through adjacent property.
Hendrescythan	BP	5.4	ST 0905 8327	Small catchment with moderate head. Penstock would be through a mix of coniferous and deciduous woodland. The proposed intake location is outside of RCT area.
Ty Rhiw	BQ	14.0	ST 1368 8472	Moderate catchment with high head. The penstock would be a mixture of trenching through pasture and laid through deciduous woodland.

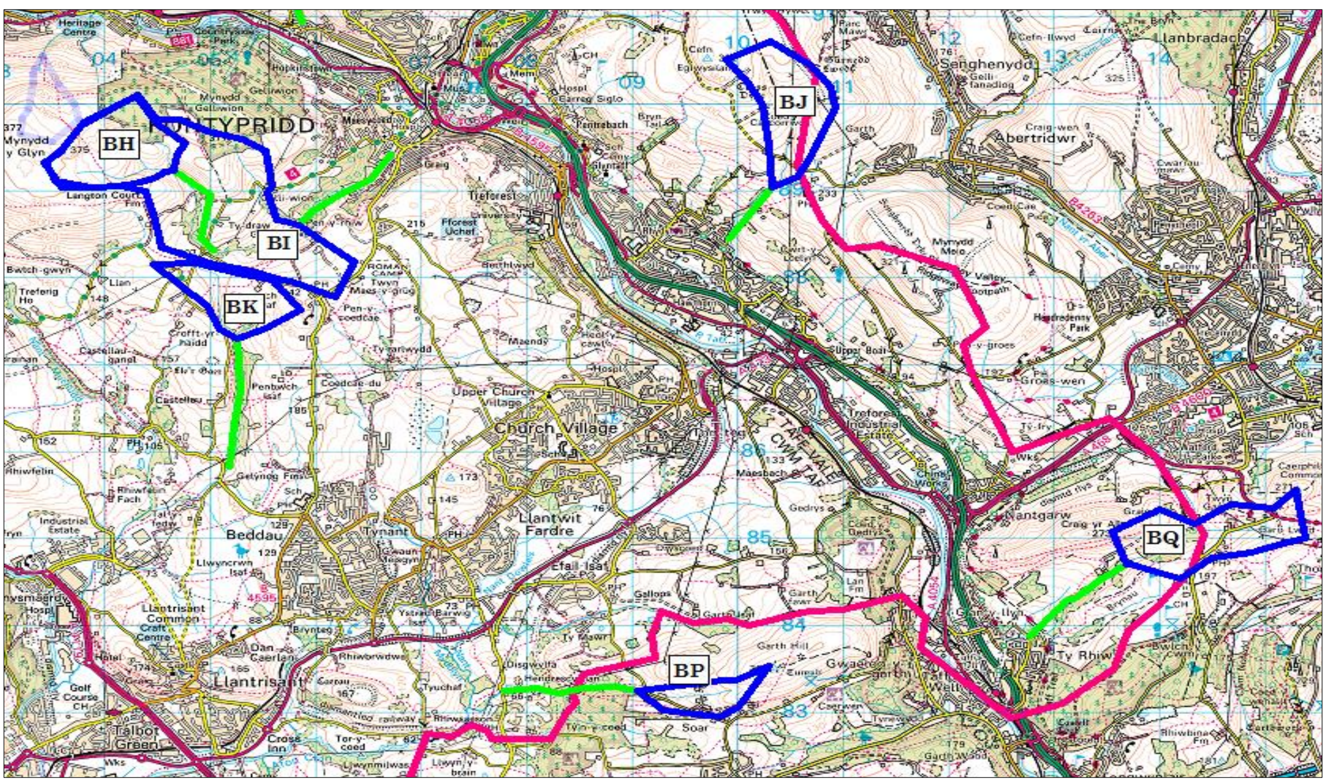


Figure 6 Location of potential micro hydro sites in South East RCT

Hydro Electric Technology

Hydroelectric plants work by converting the potential energy from water at height into electrical energy. This is achieved through water powering a turbine - using the rotational movement to transfer energy through a shaft to an electric generator.

The two basic classifications of hydro electric generators are '*High head*' and *'Low head*'. *Head* refers to the height from which the eater drops before reaching the turbine. Therefore '*low head'* refers to mills and generators in large rivers with great volumes of water that meander through the lowland valleys. *'High head'* is used to describe those systems that use only a small amount of water but can use the water once it has dropped from a great height.

To capture this potential energy in a controlled form, some or all of the water in a natural waterway can be diverted from a watercourse through an intake and into a pipe which will transport the water downhill. The pipe is smooth bored compared to the rough stream bed. There is far less friction loss in the pipe and this saved friction is the energy that is used to drive the turbine. In the turbine house at the bottom of the system the water can be directed in a focussed jet under pressure onto a turbine wheel. The rotation of the turbine and the generator, to which it is attached, convert the energy into electricity that can be exported to the national grid.

Micro hydro is typically defined as the generation of electricity from a few hundred watts up to 100kW.

Generation Calculation

Hydro power is a mature and well-understood technology that offers many advantages over other renewable energy:

- High efficiency and high power density
- Long system lifetime (up to 50 years)
- Predictable energy outputs
- Excellent load factor characteristics

The technologies required for generation differ from site to site according to various site characteristics and these are outlined below. The fundamental elements which make up the basic power generation equation are explained in below. However, there are several other factors which will reduce the *actual* power that can be generated at any site. There are multiple factors that reduce your potential energy during conversion. These include head loss in pipes, efficiency of turbines, loss in cables, and loss in inverters.

In order to simplify the calculation at the planning stage of a hydroelectric installation, these efficiency losses are assumed to amount to **50%** of the ideal calculation.

Simple power calculations can then be calculated from the flowing variables:

- **Q (flow)**: this is the amount of water that can be abstracted from a given point in a stated period of time. It is usually measured in m³/s or l/s. The abstraction limit if often limited to the annual mean flow of the river (see below for additional note on abstraction limits).
- **H (head):** This is the vertical distanced that water drops from the source to the turbine. It is measured in meters, m.
- **Gravity constant:** Also known as acceleration due to gravity, it is represented by the letter 'g' and for the purposes of this calculation can be regarded as a constant of 9.8m/s/s.
- **System efficiency:** Overall system efficiency.
- **Potential energy:** The potential output of any site is usually expressed in Kilowatts (kW)

The basic power of a system can be expressed by the equation:

- Power (in kW) = Q (in m^3/s) x H (in m) x g (in m/s/s) x Efficiency (as a fraction)

Example: At the abstraction point a watercourse has an annual mean flow of 0.03m3/s. The vertical height difference from the intake point to the turbine house is 100m. Assume a 50% system efficiency. Hydro system potential in this case would be about 0.030 x 100 X 9.8 x 0.5 = 14.7 kW.

In determining the limits of abstraction from a water course the Natural Resources Waleswill not allow any installation to abstract all of the water in a river or stream. The Natural Resources Waleshave regulations and standards to protect both the local flora and will place a restriction on the water that can be abstracted.

Stream flows are usually measured in terms of Q% values. A Q rate of Q75 represents the stream flow that is in the steam for at least 75% of the year. In most cases the Natural Resources Waleswill set an initial amount of water that must remain in the water course at all times; this is known as the Hands-off Flow (HOF). No abstraction can take place while the stream flow is less than the HOF. The HOF is usually set between Q85 and Q95.

The EA will then set the abstraction regime above the HOF. Current guidance is that abstraction can be 100% of flow above the HOF but only up to a limit equivalent to Qmean.

Hydro scheme's intake dam/weir designs and automatic flow regulators ensure that the agreed abstraction regime is maintained.

Due to the seasonal variations in flow maximum abstraction will often only be achievable for 25% of any year. High head turbines maintain good efficiencies down to about 10% of their maximum design flow, because of this the seasonal flows mean that typical high head hydro scheme will not produce significant levels of power for about 20% of any year.

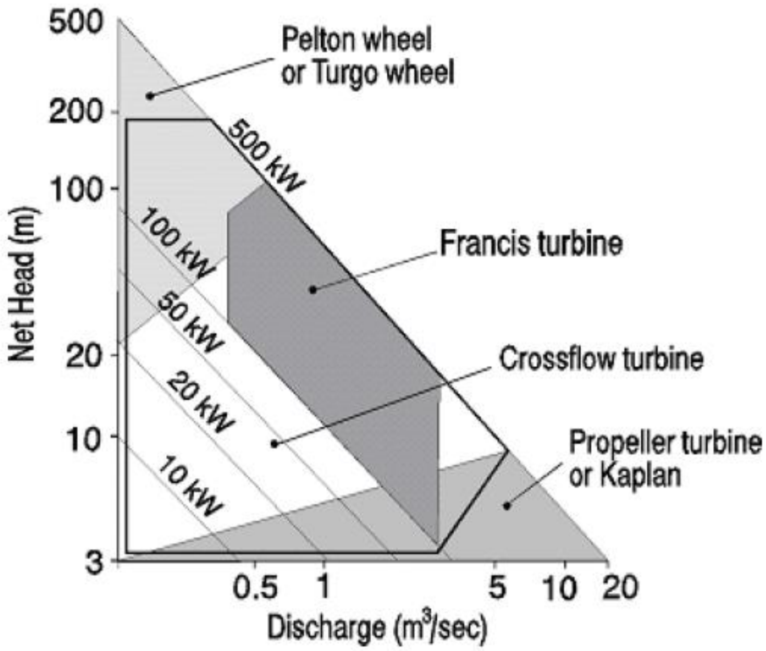
Types of hydro technology

There are several types of turbines that are used or have been used for hydroelectric generation each is adapted for conditions of flow or generation requirements. These are broadly split into two groups: Impulse turbines and Reaction turbines.

Impulse turbines rely on the speed of the water, generated by the hydraulic head - to move the wheel and are commonly used for high head hydroelectric systems.

Reaction turbines on the other hand rely on the weight of the water to move the wheel and are generally used for low head systems.

This diagram can be used to choose the appropriate turbine type once the basic flow and head data is available.



The most common turbine type used in high head hydropower installations is a *Turgo* or *Pelton* wheel. These maximise the kinetic energy transfer from the water to the wheel leaving the water drained of the kinetic energy, exiting the system very slowly. For full information and descriptions of these different turbine types please visit the British Hydro association website. The British hydro association has also published a useful guide to micro hydro.