

Hydro-power Engineers



**WATER POWER
ENTERPRISES**

**PROPOSED HYDRO POWER SCHEME, TUTBURY
MILL**

**INITIAL CALCULATIONS WITH BUDGET COST
ESTIMATIONS**

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Locations: SK 21348 29387 Tutbury, Staffordshire

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Clients: Water Power Enterprises

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Scope of work: Initial hydraulic and power output calculations with budget estimates based on the preliminary proposed layout.

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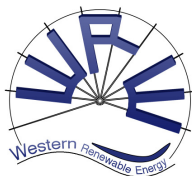
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1 Introduction

WRE Ltd carried out a site visit and initial survey of the site on 24 September 2009.

This work is limited to an initial appraisal of the site visited incorporating hydraulic and power output calculations, budget cost estimates and an initial proposed layout design.

2 General Assumptions

2.1 *Statutory approval and consultations*

At this initial stage The Environment Agency (EA) and other statutory bodies have not been consulted. Assumptions have been made based on the typical work required in liaising with the EA and local planning authority for license and planning approval.

2.2 *Estimated costs*

The civil construction works costs are the most difficult to estimate at this initial stage prior to further site investigations and detailed design. The estimated costs given for the civil works are to be used as a budget estimate only and if a fixed price is sort for this it is likely that an increase could be anticipated. As work has recently been carried out at the site it is likely there will be good information available on the ground conditions and detailed As-Built drawings of the new structures, in light of this a fixed price cost might be expected to have a relatively modest increase of approximately 20% on the civils costs.

It is assumed that there is adequate capacity in the existing Mill Fleam and tailrace and no allowance has been given for dredging or clearance of these sections of the existing watercourse.

No specific contingency has been stated with the costs at this stage.

The income of the scheme is subject to a number of variations, dependant on the route taken to sell the power.

The calculated income for the proposed scheme has been calculated based on the proposed Feed in Tariff, which is due to be introduced in April 2010.

2.3 *Design assumptions*

The following components to the design have been assumed.



2.3.1 Generator

1000 or 1500rpm asynchronous generator, due to being resilient to turbine overspeed.

2.3.2 Control system

Standard computer based hydro control system, fully automatic control of system synchronisation, water level control, data logging and data transmission.

Two options: Fixed speed or variable speed. Fixed speed is less expensive and has greater peak efficiency; variable speed is more expensive with lower peak efficiency but better part flow efficiency. However, due to the high capacity factor of the proposed turbine a variable speed system can be discounted.

2.3.3 Grid Connection

The site is considered suitable for three phase low voltage connection to an end user via an underground Steel Wire Armoured cable. In the economic analysis it has been assumed that all power is sold direct to the grid but the arrangement should allow a premium to be received over and above this amount if connected to an end user.

A suitable connection point has not been identified although connection to a three-phase cable nearby is likely to be possible.

2.3.4 Screen

130mm gap screen with horizontal or vertical steel bars at the intake to the turbine. Floating boom or other trash deflector required at the intake where practical.

2.3.5 Sluice

Fully automated sluice gate to control flow to screw turbine.

2.3.6 Fishpass

It is assumed that no provision for fish passage will be required.

3 Hydrological assessment

3.1 Head

A gross head of 2.67m was measured. However, to allow sufficient flow through the culvert in the new bridge a water depth of approximately 500mm is required and the available head is therefore 2.17m.



3.2 *Flow*

The site catchment area is approximately 876km² with an annual average rainfall of approximately 935mm.

A flow duration curve (FDC) has been calculated for the site (see Figure 1); the preliminary design flow for sizing the turbine has been taken as 1.0m³/s with a reserve flow in the River Dove of 3.6m³/s.

There are several restrictions to the flow into and along the Mill Fleam, these being a 1m diameter concrete pipe at the Mill Fleam intake and tailrace and a 2m wide by 1m deep oval culvert in the new vehicle bridge. While, the existing leat could be widened and deepened to carry an increased flow the removal of these pipes and culverts would not be possible and the flow would be restricted to approximately 1m³/s. However, a 1.0m³/s capacity turbine does have the advantage of having a high capacity factor with an improved annual energy capture (as shown below).

3.3 *Power generation*

The abstraction and the available head have been calculated to give the predicted power output shown in Figure 2 (assuming an Archimedean screw turbine).

A peak power output of approximately 14.5kW has been calculated with a capacity factor of 80%. The total annual energy capture has been calculated to be approximately 103MWh.

A full summary of the power output at different flows is given in Table 1.



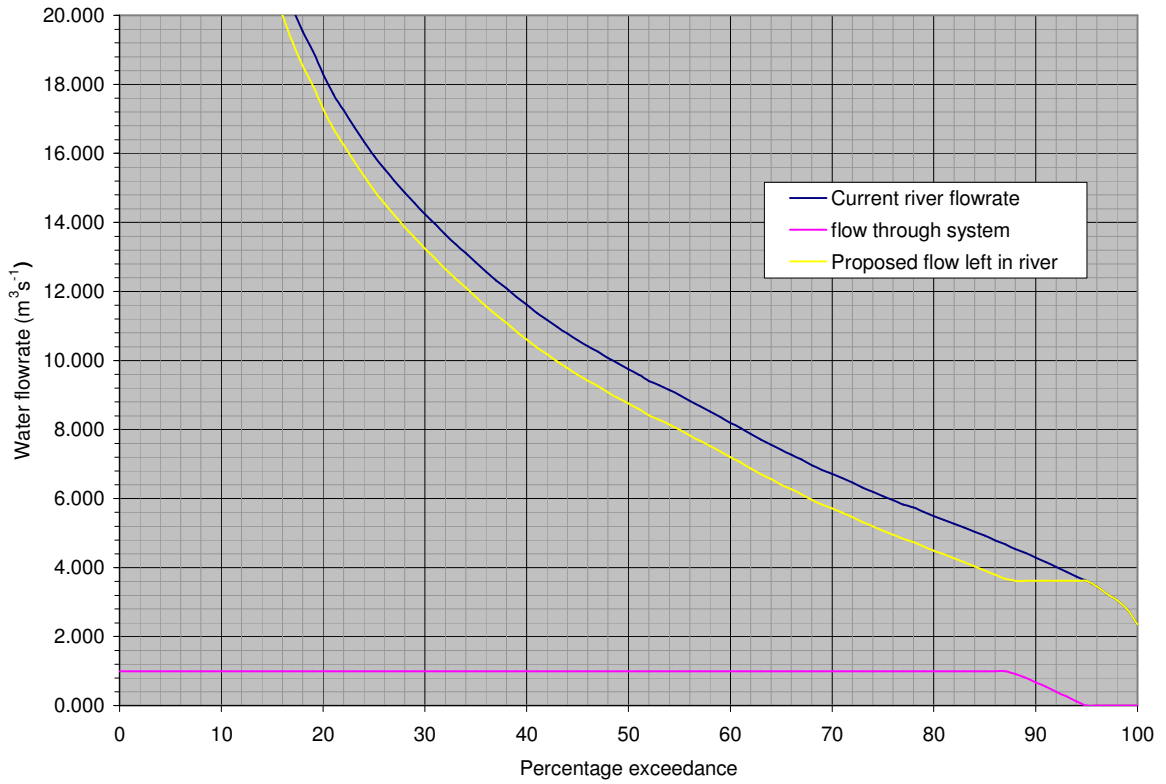


Figure 1 – FDC before and after proposed abstraction

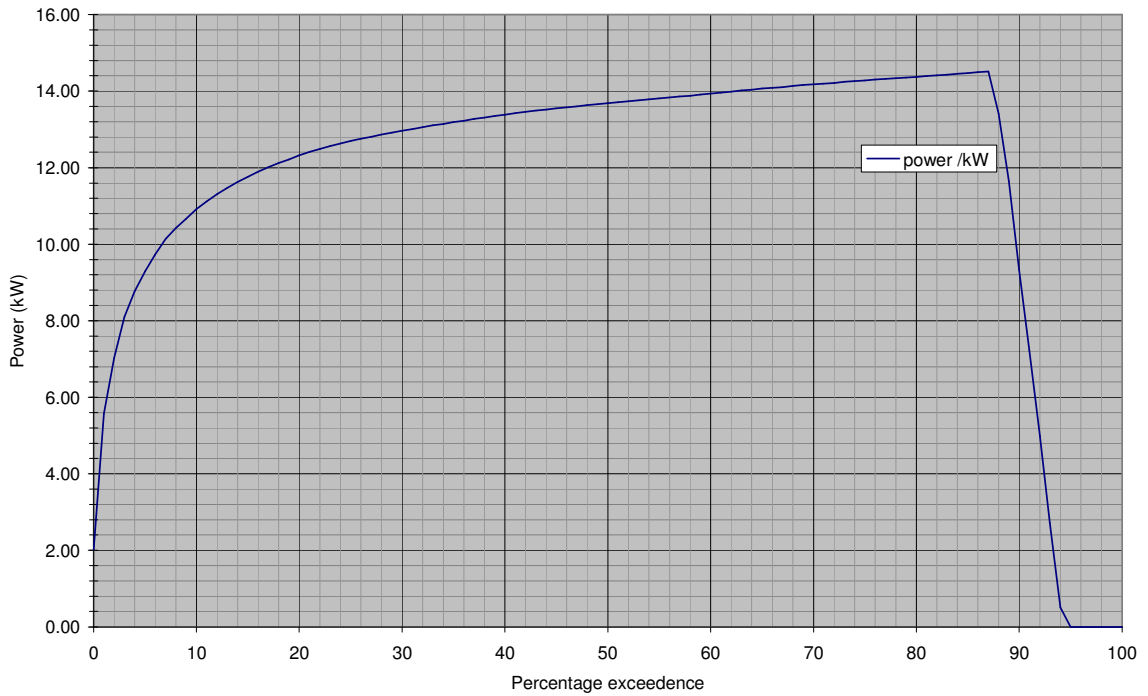


Figure 2 – Predicted power output

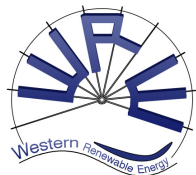


Table 1 - Power output summary

Percentage exceedence	Total flow m ³ s ⁻¹	Available flow m ³ s ⁻¹	Min residual flow m ³ s ⁻¹	Utilised flow m ³ s ⁻¹	Max Gross Head m	Net Head m	Turbine efficiency	Transmission efficiency	Generator efficiency	Water to wire efficiency	Power kW
1	63.091	59.478	33.352	1.000	2.20	0.75	0.843	0.950	0.948	0.760	5.6
5	37.829	34.216	20.721	1.000	2.20	1.25	0.843	0.950	0.948	0.760	9.3
10	27.266	23.653	15.440	1.000	2.20	1.47	0.843	0.950	0.948	0.760	10.9
15	21.840	18.227	12.727	1.000	2.20	1.58	0.843	0.950	0.948	0.760	11.8
20	18.294	14.680	10.953	1.000	2.20	1.66	0.843	0.950	0.948	0.760	12.3
25	15.919	12.306	9.766	1.000	2.20	1.71	0.843	0.950	0.948	0.760	12.7
30	14.243	10.630	8.928	1.000	2.20	1.74	0.843	0.950	0.948	0.760	13.0
35	12.844	9.231	8.229	1.000	2.20	1.77	0.843	0.950	0.948	0.760	13.2
40	11.615	8.001	7.614	1.000	2.20	1.80	0.843	0.950	0.948	0.760	13.4
45	10.593	6.980	7.103	1.000	2.20	1.82	0.843	0.950	0.948	0.760	13.5
50	9.748	6.135	9.227	1.000	2.20	1.84	0.843	0.950	0.948	0.760	13.7
55	8.997	5.384	8.997	1.000	2.20	1.85	0.843	0.950	0.948	0.760	13.8
60	8.193	4.579	8.193	1.000	2.20	1.87	0.843	0.950	0.948	0.760	13.9
65	7.404	3.791	7.404	1.000	2.20	1.89	0.843	0.950	0.948	0.760	14.1
70	6.716	3.103	6.716	1.000	2.20	1.90	0.843	0.950	0.948	0.760	14.2
75	6.068	2.455	6.068	1.000	2.20	1.92	0.843	0.950	0.948	0.760	14.3
80	5.493	1.880	5.493	1.000	2.20	1.93	0.843	0.950	0.948	0.760	14.4
85	4.922	1.308	4.922	1.000	2.20	1.94	0.843	0.950	0.948	0.760	14.5
90	4.288	0.674	4.288	0.674	2.20	1.82	0.863	0.950	0.948	0.777	9.3
95	3.613	0.000	3.613	0.000	2.20	1.27	0.000	0.950	0.500	0.000	0.0
99	2.787	0.000	2.787	0.000	2.20	1.29	0.000	0.950	0.500	0.000	0.0

Proposal	
Machine type	Archimedean screw
Max flowrate	1.00 m ³ /s
Capacity factor	80.4 %
Max output	14.51 kW
Average output	11.66 kW
Total Annual Energy Capture	103.20 MWh

Benefits		
	Cost per unit	Value
Electricity sales	£ 0.05	£ 5,160.10
Electricity savings	£ 0.08	£ -
Electricity Generation	£ 0.12	£ 12,384.25
Total		£ 17,544.35



**TUTBURY MILL HYDRO POWER SCHEME
 INITIAL CALCULATIONS AND COST ESTIMATES**

4 Scheme layout

The initial proposed layout is shown in Drawing 090923/06.

The layout shown locates the proposed turbine upstream of the new bridge in the line of the existing leat.

The leat between the existing Mill Fleam and proposed turbine intake will require dredging to ensure it is capable of conveying a flow rate of 1m³/s; a length of approximately 200m that will require dredging to a cross-sectional area of approximately 3m width by 1m depth. It is assumed that no dredging of the existing Mill Fleam or tailrace is required.

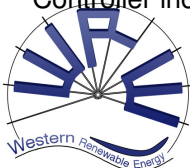
It is proposed that the turbine will discharge directly upstream of the existing culvert through the bridge; to ensure the culvert discharges the necessary volume of water it will need to flow at approximately half depth. Therefore approximately 500mm of head is lost giving a gross head of approximately 2.2m.

It has also been assumed that the abstraction of such a low flowrate will not impact on the existing fish passage at the weir on the River Dove and therefore no work will be required at the weir.

5 Financial aspects

The costs are estimations at this stage; more accurate costs would be calculated at the detailed design stage. As stated above and in the general assumptions, no allowance has been given for the dredging of the existing Mill Fleam or the tailrace as it is assumed that there is existing capacity in the watercourse and this will not be required.

	£
License and planning permission consultation and design	6,250
Environmental assessment and monitoring and other surveys	4,000
Pre-construction coordination and consents	3,750
Application fee allowance	1,000
Access allowance and site set up	3,000
Civil works	43,000
Turbine (@£1.1/€) (Ritz-Atro steel trough, 3 start)	45,000
Controller including logging and remote monitoring	9,000



Sluice gate and hydraulics	7,000
Screen	2,000
Electrical connection (c. 100m)	22,000
Installation	10,000
Commissioning	2,600
Total	<u>158,600</u>
Projected gross income (annual)	17,500
Less costs (annual)	(4,000)
Net income	<u>13,500</u>
Simple payback	12 years
Cost per kW	11,300

