Calculation Checklist

This checklist shall be used to record the site data and calculate the Hydro Abstraction Factor for the site (HAF_{site}) to allow conversion of electrical output to quantities abstracted. The HAF_{site} is the amount of water used in m^3 per kWhr generated for any period.

Site Data	
Site name	Hafod y Rhedrwydd micro-hydro
Address	Hafod y Rhedrywdd, Cwm Penmachno, LL24 0RF
Licence serial No.	
Contact name	Dr R.W.Moss
Contact telephone	07854 675742
Contact email	roger@rwmoss.co.uk
Turbine manufacturer	Hartvigsen Hydro
Turbine type	Turgo
Turbine serial no.	
Number of jets (where relevant)	1 large, 1 small per turbine (two turbines = 1 main plus 1 low power)

Performance Data		
Parameter	**Value**	**How was the parameter determined?**
Net operating head of the system at maximum power output ($H_{n\ (Pmax)}$) in metres	112.8 m (126.5 m)	Absolute maximum power would be 9.06 kW (net) at 14.2 litres/second. This is probably not a sensible operating condition due to the fall-off in rpm when losing 1/3 of the head to friction – it does not give a sensible measure of typical system efficiency (see HyR proposal v13.pdf, Figure 14). 8.8 kW (at 12.14 litres/sec) is a more sensible "maximum" operating point for both turbines running together. For completeness I am also including the maximum power from just the main turbine, 7.88 kW at 9.6 litres/sec. "Values" are at **8.8 kW (7.88 kW)**.
Turbine/water wheel efficiency at maximum power output ($e_{turbine/water\ wheel\ (Pmax)}$)	0.824 (0.826)	Manufacturer's spreadsheet (83%) less 44 W estimate of bearing and windage losses based on formulae in Thake's *Pelton design handbook*.
Transmission system efficiency at maximum power output ($e_{transmission\ (Pmax)}$)	0.843 (0.846)	Result of 4.4% losses due to cable resistance and alternator cooling fans, 150 W control system power consumption and 90% (combined) rectifier and inverter efficiency. See *system_perf8.m* lines 106-125 for the actual calculation and system_plot4.m for the output display
Generator efficiency at maximum power output ($e_{generator\ (Pmax)}$)	0.943 (0.947)	Manufacturer's data sheet (MOOG GES013 alternators).

Calculation of overall system efficiency of the rotating parts of the hydro system, at maximum power output ($e_{system\ (Pmax)}$)

$e_{system\ (Pmax)} = e_{turbine/water\ wheel\ (Pmax)} \times e_{transmission\ (Pmax)} \times e_{generator\ (Pmax)}$

= 0.824 x 0.843 x 0.943

$e_{system\ (Pmax)}$ = 0.655 (0.662)

Calculation of HAF_{site}

HAF_{site} = Hydro Abstraction Factor for the site in question

Where:

$H_{n\ (Pmax)}$ = net head at max. power.

366.972 = a constant in order to bring the final HAF into the correct unit of m3/kWhr (it is arrived at by dividing the number of seconds in an hour (3600) by gravity (9.81 m/s^2)

= 366.972 / ($H_{n\ (Pmax)}$ x $e_{system\ (Pmax)}$)

= 366.972 / (112.8 x 0.655)

= 4.97 (4.38) **(m3/kWh)**

The volume of water abstracted for any period (**V_{period}**) can then be calculated by simply multiplying the HAF_{site} by the number of kiloWatt hours generated thus:

V_{period} (m3) = kWh_{period} (kWh) x HAF_{site} (m3/kWh)

The minimum HAF is 3.806 m^3/kWh for the small alternator at 2.7 litres/sec.