Small Scale Hydro Calculator 2010

User Guide

Version 1.0 April 2010

Small Scale Hydro Calculator – User Manual

This user manual aims to give a step by step guide to those interested in using the Small Scale Hydro Calculator to estimate the output, cost, and revenue associated with a potential small scale hydro run of river scheme. The Calculator requires the use of Low Flows software, produced by Wallingford Hydrosolutions Ltd, as a means of estimating the available river flow over a year. The reasons for choosing to use Low Flows are as follows:

1. It generates annual and monthly mean flows together with their probability of occurrence.
2. Compensation flows are calculated (minimum flow which must remain in a river) as recommended by SEPA.
3. Ground composition is taken account of (water absorption).

Getting Started

In order to start using the calculator, a number of site specific inputs, together with some general ones need to be known:

Name/Location of Watercourse - Enter the name and location of the watercourse to create a heading on the page.

Intake Elevation - The height above sea level in metres at which an intake for a pipe network would be positioned and can be found using an Ordnance Survey (OS) map of suitable scale (e.g. 1:25000) or GPS reading.

Turbine Elevation - The height above sea level in metres at which a turbine will be positioned and can be found using an Ordnance Survey (OS) map of suitable scale (e.g. 1:25000) or GPS reading.

Pipe Length - Length of pipe in metres required to connect an intake with a turbine.

Turbine Eff. - The overall efficiency in percent of a turbine and generator combination as given by the equipment manufacturer.

Kinematic Viscosity - The kinematic viscosity of the working fluid in m^2/s, in this case water. As viscosity changes with temperature, a suitable value should be chosen from the table below.

Temperature (°C)	Kinematic Viscosity (m^2/s)
0	1.787×10^{-6}
5	1.519×10^{-6}
10	1.307×10^{-6}
20	1.004×10^{-6}

Roughness Coefficient - The roughness coefficient of the material from which piping in the pipe network is constructed from.

Once this information is known, it can be entered in the white cells of the calculator as shown in the example below:

Small Scale Hydro Calculator

Name/Location of Watercourse: Corrie Henzie, Glen Almond

Intake Elevation (m)	400
Turbine Elevation (m)	250
Head (m)	150
Pipe Length (m)	1200
Hydraulic Gradient	0.1260
Turbine Eff. (%)	80

Kinematic Viscosity	1.31E-06
Roughness Coef (mm)	0.003

The head of the system (the difference between the intake and turbine elevations) in metres and the hydraulic gradient of the system are then calculated and displayed.

LowFlows Summary

For information on the use of LowFlows in order to complete this section read the documentation accompanying the software or if you do not have access to the software contact Wallingford Hydrosolutions Ltd as they also offer a flow retrieval service which will provide the information you require:

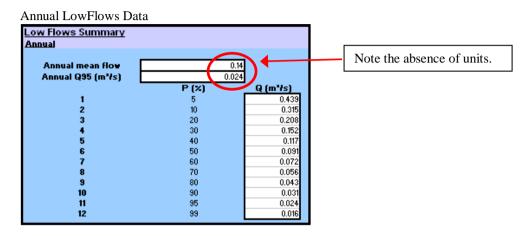*Annual Mean Flow* - The predicted mean flow over a year

Annual Q95 - The compensation flow (also known as the environmental flow). This is the predicted minimum flow of water in m^3/s required to remain in the watercourse for 95% of the year. This means only flows greater than the annual Q95 will enable generation to take place as:

Extracted Flow = Available Flow minus Q95 Flow

Monthly Mean - The predicted mean flow over a particular month.

Q95 – The predicted minimum flow of water in m^3/s for 95% of the time in a given month.

P(%) – The probability in percent of a flow occurring.

Q(m^3/s) – The predicted flow corresponding to a flow probability in m^3/s.

Important Note: The cells containing the Annual Mean Flow and the Annual Q95 values should only contain a number. If units are also present, e.g. m^3/s, the calculator will not function correctly.

Here, annual and monthly data obtained from LowFlows for the site of interest should be entered in the white cells of the calculator as shown in the examples below:

Annual LowFlows Data

Low Flows Summary		
Annual		
Annual mean flow		0.14
Annual Q95 (m³/s)		0.024
	P (%)	Q (m³/s)
1	5	0.439
2	10	0.315
3	20	0.208
4	30	0.152
5	40	0.117
6	50	0.091
7	60	0.072
8	70	0.056
9	80	0.043
10	90	0.031
11	95	0.024
12	99	0.016

Note the absence of units.

Monthly LowFlows Data

Monthly	Jan	Feb	Mar	Apr
Monthly mean	0.23 m³/s	0.20 m³/s	0.18 m³/s	0.13 m³/s
Q95	0.059 m³/s	0.052 m³/s	0.051 m³/s	0.041 m³/s
P (%)	Q (m³/s)	Q (m³/s)	Q (m³/s)	Q (m³/s)
5	0.616	0.693	0.505	0.3
10	0.491	0.453	0.388	0.2
20	0.353	0.289	0.273	0.1
30	0.266	0.214	0.21	0.14
40	0.215	0.169	0.169	0.11
50	0.18	0.136	0.136	0.09
60	0.147	0.11	0.111	0.08
70	0.12	0.09	0.092	0.0
80	0.095	0.075	0.077	0.0
90	0.071	0.06	0.06	0.0
95	0.059	0.052	0.051	0.
99	0.046	0.041	0.041	0.0

	Aug	Sep	Oct	Nov	Dec
	4 m³/s	0.10 m³/s	0.16 m³/s	0.20 m³/s	0.23 m³/s
	6 m³/s	0.018 m³/s	0.025 m³/s	0.045 m³/s	0.052 m³/s
	(m³/s)	Q (m³/s)	Q (m³/s)	Q (m³/s)	Q (m³/s)
	0.23	0.311	0.478	0.573	0.645
	0.156	0.227	0.35	0.425	0.5
	0.1	0.15	0.231	0.291	0.34
	0.073	0.109	0.18	0.215	0.252
	0.054	0.08	0.141	0.175	0.2
	0.042	0.062	0.111	0.143	0.162
	0.035	0.048	0.086	0.116	0.131
	0.029	0.039	0.067	0.093	0.11
	0.024	0.031	0.05	0.074	0.089
	0.019	0.022	0.035	0.055	0.065
	0.016	0.018	0.025	0.045	0.052
	0.014	0.015	0.014	0.031	0.033

Cost of System

In this part of the calculator costs for a scheme are estimated based on the data entered. Note that the costs are not definitive but best estimates at the time of compilation based on feedback from a number of sources.

The first user input required is for Sizing Turbine:

Turbine Rating (kW) - Output of the proposed turbine in kW.

Under Operational Range some system flow rates associated with the Turbine Rating are shown

Cost Breakdown contains the various estimated costs for the proposed scheme as follows:

Est. Pipe Cost (per m) – Estimated pipe cost per meter in £ based on the pipe diameter.

Est. Cost of Pipe – Estimated total cost of pipe in £ using estimated pipe cost per meter and given pipe length.

Est. Cost of Turbine – Estimated cost of turbine in £ based on the Turbine Rating.

Groundwork/Powerhouse – Expected cost in £ for site groundwork and powerhouse construction.

Transmission Distance (km) – Amount of transmission cable required to join the powerhouse to the national grid in kilometres. Enter the amounts of overhead and underground cable required under the appropriate transmission voltage.

Est. Transmission Cost – Estimated transmission cost in £ including cabling, switchgear and transformer.
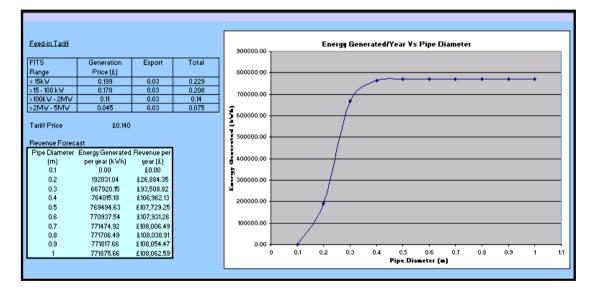
Est. CapEx - Estimated capital expenditure in £ of proposed scheme.

Est. OpEx - Estimated operating expenditure in £ of proposed scheme.

After entering the Turbine Rating value, the Tariff Price which the installation will qualify for will be displayed below the Feed-in Tariff table. It is assumed that all the electricity generated is exported to the national grid.

Cost Of System

Sizing Turbine

Turbine Rating (kW)	250.00
Chosen Pipe Diameter (m)	0.4

Operational Range

Rated Flowrate (m^3/s)	0.2124	
Turbine	Cut in flow	Cut out flow
	0.074328916	0.2654604

Cost Breakdown

Est. Pipe Cost (per m)	£113.22
Est. Cost of Pipe	£135,858
Est. Cost of Turbine	£205,400
Groundwork/Power House	£50,000 include the costs for powerhouse

Transmission Distance (km)	11kV	33kV
Overhead		0
Underground		

Est. Transmission Cost	£0.00
Est. CapEx	£391,258
Est. OpEx	£22,350

Below this is the Forecasted Revenue per year in £ using the Tariff Price for a range of pipe sizes based on the turbine rating and the corresponding energy generated over the course of a year.

Feed-in Tariff

FITS Range	Generation Price (£)	Export	Total
< 15kW	0.199	0.03	0.229
>15 - 100 kW	0.178	0.03	0.208
>100kW - 2MW	0.11	0.03	0.14
>2MW - 5MW	0.045	0.03	0.075

Tariff Price £0.140

Revenue Forecast

Pipe Diameter (m)	Energy Generated per year (kWh)	Revenue per year (£)
0.1	0.00	£0.00
0.2	192031.04	£26,884.35
0.3	667920.15	£93,508.82
0.4	764015.18	£106,962.13
0.5	769494.63	£107,729.25
0.6	770937.54	£107,931.26
0.7	771474.92	£108,006.49
0.8	771706.49	£108,038.91
0.9	771817.66	£108,054.47
1	771875.66	£108,062.59

Energy Generated/Year Vs Pipe Diameter

The graph to the right of the calculator page plots the predicted energy generated per year with pipe diameter. Although the amount of energy generated is primarily determined by the turbine rating, assuming suitable water flow, too small a pipe diameter will reduce the amount of energy generated while too large a diameter will increase the capital costs of the system without increasing the amount of energy or revenue generated.

It is necessary for the user to select a suitable pipe diameter using the graph and to enter this value in the Chosen Pipe Diameter cell below the Turbine Rating.

Payback Period

This final section takes into consideration the economic outputs from the previous section and uses them to form a 20 year economic projection, the amount of time a hydro FIT is currently guaranteed for, based on the following inputs:

Tax Rate – Tax rate in percent that any earnings from the proposed scheme are likely to be taxed at.

Long Term Interest Rate – Interest rate in percent available for a capital loan.

Long Term Inflation Rate – Inflation rate assumed to be the average over a 20 year period.

% of Profits to Debt Repayment – Percentage of profit used each year to repay debt.

Tax rate		35 %		Turbine (kW)	250.00				
Long term interest rate		7 %		Pipe Dia. (m)	0.40				
Long term inflation rate		2 %							
% of profits to debt repayment		100 %							

Year	Investment Balance	Generation Income	Debt Interest Repayment	Annual OpEx	Total Outgoings	Pre-Tax Profit/Loss	Net Profit/Loss	Cumulative Profit/Loss	Debt Capital Repayment
1	£391,258	£106,962	£27,388	£22,350	£49,738	£57,224	£37,196	-£354,062	£37,196
2	£354,062	£109,101	£24,784	£22,797	£47,581	£61,520	£39,988	-£314,074	£39,988
3	£314,074	£111,283	£21,985	£23,253	£45,238	£66,045	£42,929	-£271,145	£42,929
4	£271,145	£113,509	£18,980	£23,718	£42,698	£70,811	£46,027	-£225,118	£46,027
5	£225,118	£115,779	£15,758	£24,192	£39,951	£75,829	£49,289	-£175,829	£49,289
6	£175,829	£118,095	£12,308	£24,676	£36,984	£81,111	£52,722	-£123,107	£52,722
7	£123,107	£120,457	£8,618	£25,170	£33,787	£86,669	£56,335	-£66,772	£56,335
8	£66,772	£122,866	£4,674	£25,673	£30,347	£92,519	£60,137	-£6,635	£60,137
9	£6,635	£125,323	£464	£26,187	£26,651	£98,672	£64,137	£57,502	£64,137
10	£0	£127,830	£0	£26,710	£26,710	£101,119	£65,728	£123,229	£0
11	£0	£130,386	£0	£27,245	£27,245	£103,142	£67,042	£190,272	£0
12	£0	£132,994	£0	£27,789	£27,789	£105,205	£68,383	£258,654	£0
13	£0	£135,654	£0	£28,345	£28,345	£107,309	£69,751	£328,405	£0
14	£0	£138,367	£0	£28,912	£28,912	£109,455	£71,146	£399,551	£0
15	£0	£141,134	£0	£29,490	£29,490	£111,644	£72,569	£472,119	£0
16	£0	£143,957	£0	£30,080	£30,080	£113,877	£74,020	£546,139	£0
17	£0	£146,836	£0	£30,682	£30,682	£116,154	£75,500	£621,639	£0
18	£0	£149,773	£0	£31,295	£31,295	£118,477	£77,010	£698,650	£0
19	£0	£152,768	£0	£31,921	£31,921	£120,847	£78,551	£777,200	£0
20	£0	£155,824	£0	£32,560	£32,560	£123,264	£80,122	£857,322	£0

What the situation would be after the FITs guarantee period is exceeded is uncertain. Therefore it is advised that any payback period falls within the guaranteed period.