micro hydro in the UK

a case for special consideration

Micro Hydro Association
assisting with the creation and operation of hydro-electric schemes in Britain
www.microhydroassociation.org

Introduction and summary

Purpose of paper

This paper sets out two propositions to improve local generation of electricity using very low impact hydropower (“micro hydro”) where suitable watercourses exist in the UK.

The aim is to demonstrate to politicians, government departments, authorities, and regulatory agencies how long term benefits can be gained, at low risk and low cost, in encouraging the deployment of micro hydro schemes by simplifying regulatory constraints and by moving to a reduction of the present level of incentivising subsidy via the Feed-in Tariff (FiT).

The proposals are further developed from ideas put forward in various consultations and submissions by the Micro Hydro Association from 2010-2012.

The proposals are to:

1. **provide a registration process for micro hydro schemes that meet criteria to ensure a negligible risk of adverse impact**

2. **provide a loan-based funding mechanism to reduce the cost to the taxpayer/electricity consumer of the Feed-in Tariff whilst retaining a reasonable incentive to landowners and developers**

3. **initiate actions to increase hydropower employment opportunities, scheme quality and distribution network adaptability.**

There is a wealth[1] of UK water resource suitable for micro hydro but very little of this resource is being exploited despite the FiT incentive[2]. This resource should be exploited as soon as possible in order to make a contribution to reducing carbon emissions, and to improving the economy, particularly in rural areas.

Small scale hydro schemes have in the past lasted for over 100 years. With modern materials and electronic controls this now should be equalled or bettered. If the proposals are adopted there is a good chance that the UK will have a valuable new contribution to electricity generation; if nothing is done, very little will be gained from micro hydropower.

Authorship and circulation

The author, Gavin King-Smith is the administrator of the Micro Hydro Association (mha)[3]. The mha is a comprehensive focal point for micro hydro in the UK with 170 members comprising practitioners and existing and potential generators. Members of the mha and others known to have an interest have contributed their views through a survey and review of earlier drafts of these proposals published on the mha website. This draft will also be published on the mha website.

I am now circulating the paper in draft form to government departments (initially DECC) with the aim of refining the ideas before widening distribution to other parties who currently play some part in the regulation of hydropower development and operation.

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[1] based on a survey by the author of over 300 specific sites and on surveys commissioned by the Environment Agency and by the Scottish Government from 2008 to 2010

[2] see Appendix V micro hydro schemes commissioned under FiT scheme

[3] www.microhydroassociation.org

Registration process

In a recent survey of members of the mha, all responders endorsed a registration approach as simplified alternative to licensing for very low impact hydro schemes (typically 5-30kW capacity, but ranging from 1-100kW)[4]. In order to make registration of micro hydro schemes acceptable, many agencies will need to be satisfied that the design and ecological criteria applied will achieve the aims of the present regulation. Scheme developers will therefore need to demonstrate in their submission for registration, and in scheme design documents, that they will provide appropriate ecological protection and will conform to construction guidelines, electrical regulations, and riparian rights. (Ofgem also require registration through the ROOFIT process to gain eligibility for the Feed-in Tariff).

Based on consideration of the survey responses, present regulatory requirements used to permit hydropower, and knowledge of schemes which have been permitted to date, I am proposing a set of simplified principles and specific criteria which could be used for registration of micro hydro schemes. An applicant for registration of a scheme would need to confirm that the complete set of registration criteria will be met and support this with a design statement. Where any of the criteria could not be met, an applicant would be expected to provide additional evidence to satisfy the competent authority that registration was still an appropriate route rather than reverting to the usual licensing process used currently for both high and low impact hydro scheme developments.

The most appropriate location for the register of schemes could be either the planning authority or the environment agency responsible for the area predominantly covered by the scheme (though this could on occasion straddle more than one authority /agency). The registration document and design statement should be available to all authorities.

Principles for micro hydropower regulation and suggested criteria are set out in APPENDIX I Proposed principles and criteria for registration process. These aim to encompass all the existing regulatory principles and processes but in a simplified manner. They are designed to be used as the basis for a front-end procedure for regulation by the agencies (EA, SEPA, NIEA, NRW) thus avoiding the need for prolonged and detailed licensing processes for low impact schemes and reducing the agencies' workload.

[4] see Appendix III sample analysis of over 300 potential and actual schemes (mainly in Scotland) - capacities

Support for capital investment and a better deal for the electricity consumer - Feed-in Tariff modifications

The current FiT fails to address the difficulty that many face in obtaining up-front development capital for micro hydro schemes at capital costs which can range from £5,000 for tiny self-build schemes to over £200,000[5]. This level of funding can be difficult to obtain for individuals and, together with burdensome regulation, has contributed to the limited rate of uptake of the FiT scheme for micro hydro - see Appendix V micro hydro schemes commissioned under FiT scheme.

This proposal suggests that the high capital cost-effectiveness of micro hydro, coupled with the high load factors achievable (typically 40 - 65%[5]) could be used to reduce the cost of the FiT subsidy to the consumer. The proposed approach would divert initial FiT payments into repayments of a capital loan. Once a significant part of capital costs have been recovered for a scheme, a lower FiT rate would be applied.

I propose that loans are provided from a protected element of the Green Investment Bank fund or the Green Deal fund.

Loans would be repaid, with interest, from the initial FiT payments (generation and export) due to the scheme owners. Typical payback periods for well-designed micro hydro schemes are 2-6 years from start of operation (assumes cost of finance is 7%). Because there is no cost to the Exchequer, there should be no issue with contravening European funding legislation as has been the case with grant funding. The loan would be of a fixed sum depending on the capacity of the hydropower scheme and would have to be repaid within a fixed period. It would need to be available for draw-down early during the development period (1-3 years from conception).

The scheme owner would benefit in the fixed capital repayment period from the use of “free” electricity displacing imported electricity. For the remainder of the FiT period the scheme owner would also receive a generation tariff plus the guaranteed (or negotiated) export tariff to contribute to recouping any outstanding private capital investment. After the FiT period, the scheme owner would continue to benefit, not only from free electricity, but also from negotiating the sale of 100% renewable source electricity to suppliers.

This approach would reduce the cost of the FiT to electricity consumers through suppliers but would still provide a good incentive for people to install hydro schemes on viable watercourses.

The FiT/loan scheme and associated procedures could be trialled for a year in critical areas such as Scotland and Wales. In order to retain certainty for a reasonable period, particularly for the larger, longer timescale, hydro developments already in the pipeline, I suggest that the present FiT structure be retained in parallel with the trial for the next 2-3 years when I understand the FiT scheme will again be reviewed. This will also provide time for the new approach to be validated and refined by all stakeholders and for any necessary statutory orders to be drawn up.

Further details and examples of how the scheme would operate are given in APPENDIX II Proposed changes to FiT and examples of impact.

[5] see Appendix IV sample analysis of potential and actual schemes (mainly in Scotland) – costs and performance

Other key points for action

There are both opportunities for, and other constraints militating against, delivery of benefits from micro hydropower. They are outlined below with the aim of initiating a dialogue with those who can contribute.

Opportunities

Rural and community sustainability

The UK is blessed with high rainfall particularly in hilly rural areas and this is likely to remain the case. Hydropower has been used on the very small scale in the past but fell into disuse with the advent of electricity and the National Grid. With increasing carbon-based energy costs and pressures to use sustainable energy sources there is now also an opportunity for rural and other communities to enhance their local economies where water resources exist. There are opportunities for communities to share experience across the UK and for DEFRA and Local Authorities to encourage low impact hydropower developemt in these locations.

Hydropower employment opportunities

The hydropower industry is at present dominated by large scale enterprises, often importing equipment from abroad. These suppliers do not offer installation and supply for micro hydro schemes below around 30kW capacity, and charges from larger organisations for schemes up to 100kW can be unnecessarily high owing to the bespoke nature of each scheme and the overheads such enterprises have to bear. There is a shortage of engineers with the skill and experience to design and implement micro hydro schemes; this imposes a resource constraint on the rate at which micro hydro can be developed but on the other hand presents an opportunity for job growth in this industry sector.

The installation of a hydropower scheme involves specialized design (hydraulic design, CAD design, and terrestrial and ecological surveying), electrical and electro-mechanical design, civil works (trench digging and pipe laying, intake structure construction), engineering (fabrication of turbine components, and manufacture of generator and electrical control equipment), and grid connection/commissioning. There are fewer than ten suppliers manufacturing the key turbines and grid connection equipment for micro hydro, mostly sole practitioners employing or contracting out to a handful of people and there is limited practical experience amongst the organisations offering installation services.

As yet there are scarcely any courses offering suitable specific training for hydropower manufacture or installation. The physics is not hard and the technology is mature in design and concept terms, so universities and university technical colleges should be able to adapt courses easily, given input from skilled and experienced designer/installers, and to encourage placements and mentoring schemes.

Apprenticeship would be the most realistic way for student engineers to gain practical experience with the few organisations that are designing and installing micro hydro schemes. However this would need to be funded owing to the small size of the existing organisations.

I suggest that this is an opportunity to be addressed by the Department for Business, Innovation and Skills and the Department of Education. A first step would be to open a dialogue with a few of the current micro hydro designer/installers.

Scheme quality

The initial attempt to include hydropower within the MCS framework (used for accreditation of installers and products for mass renewable technologies such as solar panels) proved inappropriate to the bespoke nature of hydropower schemes. Potential scheme owners and regulators still want a workable approach for assuring the performance, security, resilience, and longevity of hydropower schemes. This is not solely for the owners' financial benefit and for protection of the public and the environment, but also for the long term contribution hydropower makes to cost-effective clean energy supply.

One suggested approach would be the formation of a guild of experienced micro hydropower engineers who could carry out peer design reviews. Open registration and publication of the designs and performance of implemented schemes would also help generate confidence in the providers of equipment and services.

A voluntary design and/or post implementation review service for individual schemes such as that being developed by Gastec[6] could be useful if suitably experienced reviewers were to be involved.

To progress these approaches, I propose that DECC consult people in the industry on their viability.

Constraints

Distribution network adaptability

In a number of locations where schemes are most likely to be cost-effective, particularly in rural hilly areas, 11kV power lines or control equipment at local substations may need to be upgraded to connect one or more schemes at their optimum capacity. In such cases, the "savings" in FiT subsidy could usefully be vired towards the costs of upgrade which would otherwise render individual schemes non-viable. This is a wider issue which could be addressed through Ofgem with network operators in the context of the expansion of all types of embedded distributed generation.

Grid connection standards and procedures

Changes to the standards for embedded generation (G83 and G59) have recently been updated to provide consistency in delivery of supply. Implementing the revised standards has presented an additional barrier to very small scale hydropower development by increasing the costs of small type-testing grid connection controllers. This could be mitigated by DNOs sharing information from witness tested sites so that unnecessary duplication and cost is avoided.

The time to obtain agreement by DNOs for connections and the demands for up-front fees to reserve connection capacity imposes a burden for some schemes. These are issues still being considered by Ofgem.

Basis for Feed-in Tariff banding

The present banding of tariffs based on capacity leads to schemes being designed to fit the banding (see Appendix V micro hydro schemes commissioned under FiT scheme). It can also lead to unnecessary arguments between Ofgem and generators with schemes close to the capacity boundaries when more energy is generated in a high and evenly spread rainfall year than would be expected in an average year. Rainfall in some years can be double that in others. An appropriate mechanism would be to set the tariff on a sliding scale based on energy produced. This would be simple to administer and should be considered again in the next FiT review.

[6] Gastec CRE are a member of KIWA Ltd and a UKAS accredited Notified Body

APPENDIX I Proposed principles and criteria for registration process

The proposed criteria following this page are designed to meet the ***precautionary principles below*** (which apply to all hydropower schemes). Hydropower schemes seeking registration will need to meet the principles by taking the actions noted in the bullet points.

A hydro scheme should not:

risk significant damage to or reduction in the fish population in the river basin as a whole*

- screen the entry of water at the abstraction point and screen outflow to avoid access to turbine
- limit disturbance of water and bed of watercourse at outflow
- ensure a hands-off flow (where water available) which will provide sufficient river bed coverage and flow so as to sustain any important habitat or food resource
- where there is significant use by fish of any affected reach of water (as judged by qualified walk-over survey and where appropriate electro-fishing): if there will be any weir re-construction or new structure exceeding the height of natural obstacles, provide suitable alternative fish passage up and down the watercourse and protect fish spawning habitat (e.g. weirpools) against adverse changes in flows

reduce availability of water habitat for fish or other protected species in a river basin*

- ensure a hands-off flow to provide sufficient river bed coverage and flow to sustain any important habitat or food resource (when water is available)
- mitigate adverse changes in sedimentation resulting from impoundment changes by mechanical means

increase risk of flood damage from a watercourse

- demonstrate that the net effect of raising the level of the watercourse or impoundment, and of diverting water from existing flows, does not significantly increase the potential risk of flooding surrounding land or property or reduces the risk

impact other (prior) water uses adversely or should compensate those affected

- contact all other affected users (e.g. livestock farmers, fish farms, canoe clubs, water companies) and agree any mitigation measures needed to allow continued use or agree compensation

damage land habitat of protected species

- in areas known or likely to provide critical support to protected species, conduct qualified ecological walk-over surveys to determine population and to confirm no significant impact from building or operating the hydro scheme – design mitigation measures if necessary
- avoid identified breeding or dwelling sites when building access tracks, foundations, laying pipes, etc.

create unacceptable noise in a populated or frequented area

- fit turbine houses with sound insulation if located in such an area

create unsightly structures in urban areas or places of natural beauty

- build small turbine houses using appropriate materials

create electrical or other safety risks

- notify/obtain connection offer from DNC via the appropriate procedure
- meet current electrical installation standards
- erect suitable barriers and signs where there could be risk of public access to moving equipment

* these principles address Water Framework Directive requirements for quality standards of watercourses designated as Water Bodies.

REGISTRATION CRITERIA FOR MICRO HYDRO SCHEMES

In order to meet the above principles, the applicant will be required to confirm that the following criteria are met (under three headings: Design, Ecology, Other):

Design

1 **the design flow/capacity (DNC)** relationship falls within the following bounds.:

any scheme where design flow <= Q_{70} and DNC <100kW[7]

schemes where design flow >Q_{70} and < =Q_{mean} × 1.5 (≈ Q_{20}), capacity (DNC) <50kW, and residual flow in any depleted reach immediately below the abstraction point always exceeds Q_{95} (when available) or Q_{90} where fish are present (see 6 below)

2 **design flow** <= Q_{mean} × 1.5, and **residual flow** immediately below the abstraction point always exceeds Q_{95} (when available) or Q_{90} where fish are present (see 6 below)

3 **depleted reach**

either there is a >1:20 (5%) average gradient measured along the depleted reach

or the habitat in a shallower depleted reach is of no ecological significance in the context of the river basin (see 6 below)

or there is no depleted reach (as in an on-weir scheme)

4 **the height of the intake structure** does not create an additional flood risk andis lower than the highest natural obstacles (to fish) in the depleted reach where fish are present (see 6 below) and upstream *or* agreement has been reached with the local fisheries body for mitigation (e.g. a series of pools stepping up to the weir crest)

5 **the catchment area** of the watercourse above the intake is <10km^2 for a design flow of Q_{mean} × 1.5; the area could be inreased proportionally for design flow < Q_{mean} × 1.5 or flow split schemes – i.e. catchment (km^2) < 10 × (Q_{mean} × 1.5)/ Q_{design}

Ecology

6 a qualified[8] walkover survey, or local expert opinion, has confirmed that in respect of expected changes in the geomorphology and ecological habitat afforded by the depleted reach (where there is one) :

either there are no protected fish or other protected species ,

or the population that could potentially be affected is insignificant in relation to the remaining population in the same river basin

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[7] the suggested upper limit of 100kW is illustrative and in most cases schemes of over 50kW will potentially have some impact on the environment which should be carefully considered, and the abstraction and any impoundment licensed. However, there will also be schemes of this capacity which will clearly have negligible environmental impact and are therefore suitable for the proposed registration approach. For example, a 200m high head scheme using water from a 6km^2 high rainfall catchment area abstracted from the top of a cliff close to the sea would require a design flow of only ~21% (Q70) of mean flow to generate 750MWh/annum at a maximum power of 100kW. The turbine would require a 17.5cm diameter turgo runner and the penstock would have an external diameter of 250mm.

[8] this could be carried out by the landowner where able to demonstrate good knowledge of ecology (e.g. where environmental agencies or fisheries boards are already satisfied with the landowner's ecological credentials) or by a qualified ecologist and/or fishery expert.

and the design will ensure that any protected species on land will suffer no significant impact from building or operating the hydro scheme and that identified breeding or dwelling sites will be avoided when building access tracks, foundations, laying pipes, etc.

Other

7 no heritage or otherwise controlled areas or buildings are affected or relevant consents are being obtained

8 all neighbouring property owners are notified and confirmed not opposed to scheme

9 whole scheme lies on own land or agreement is being formalised with affected parties

10 penstock (if any) is to be buried where feasible and otherwise secured safely

11 turbine house footprint will be < $30m^2$ and walls sound insulated if within earshot of habitation or frequented nature location

12 where the scheme is to be grid connected, the DNO is being notified via the standard procedure appropriate for the power to be connected

13 electrical and safety regulations are being followed

14 there are no adverse impacts on the character of buildings or landscape.

APPENDIX II Proposed changes to FiT and examples of impact

Loan and payback mechanism

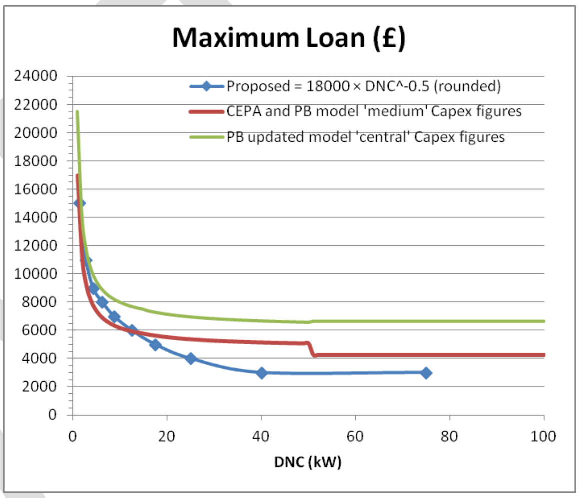
A capital loan will be made available up to a maximum value according to scheme capacity on a sliding scale. Loans will be set for a fixed maximum repayment period at a fixed rate of interest with automatic reduction by amounts equivalent to the Feed-in Tariff generation and export payments awarded within that period.

The proposed maximum loan amounts could be calculated by formula such as the following, designed to reflect the average cost/kW capacity (DNC):

$$\textbf{Maximum Loan (£)} = 18000 \times DNC^{-0.5} \text{ (rounded)}$$

This gives a sliding scale of capital cost from £17,600/kW DNCfor a 1kW DNC pico scheme to £2500/kW DNC for a 100kW scheme. This corresponds to typical scheme cost estimates for capital-efficient hydropower schemes (mha view).

DNC (kW)	mean DNC	cost/kW (£)
>=1.0 & <2.0	1.5	15000
>=2.0 & <3.7	2.85	11000
>=3.7 & <5.0	4.35	9000
>=5.0 & <7.5	6.25	8000
>=7.5 & <10.0	8.75	7000
>=10.0 & <15.0	12.5	6000
>=15.0 & <20.0	17.5	5000
>=20.0 & <30.0	25	4000
>=30.0 & <50.0	40	3000
>=50.0 & <100.0	75	3000



(the formula could be revised as considered appropriate, for example by using the original "medium" Capex figures suggested in the final CEPA PB report[9] or the updated "central" Capex figures suggested in the Parsons Brinckerhoff report[10] - these are illustrated in the graph above for comparison).

Interest could be charged annually at, say, 5% (or 2% above RPI).

The loan repayment period could be set at, say, 5 years so that the more capital efficient schemes will be better incentivised than the less efficient. The loan would be repaid through diverted FiT payments augmented by any capital repayments made by the owner, with the final outstanding loan being cleared by the owner by the end of the loan period.

Opportunity for reduced FiT payments after loan repaid

The author considers that the highest value, low impact, micro hydro potential schemes should be given greatest priority, but also that for these in particular the current levels of Feed-in Tariff for generated output could be reduced. Two examples of implemented schemes, one high head and one low head, illustrate the internal rate of return and average cash flows if the proposed loan and payback mechanism is used and illustrating the impact of current and reduced tariffs after loan repayment. This proposal is not endorsed by some installers and would not generally apply to low head schemes where civil works, turbine, and ancillaries such as a screen cleaner can increase costs.

[9] 4307-pb-and-cepa-updates-to-fits-model-documentation-o original.pdf (Available from DECC)

[10] 5900-update-of-nonpv-data-for-feed-in-tariff-.pdf (Available from DECC)

High head example cash flow projection

This example is based on a scheme which was commissioned recently. It involved a degree of "self-build" by the landowner, hence the relatively low cost/kWh capacity. In this example, a reduction of 25% in the generation tariff after the 5 year loan repayment period is used.

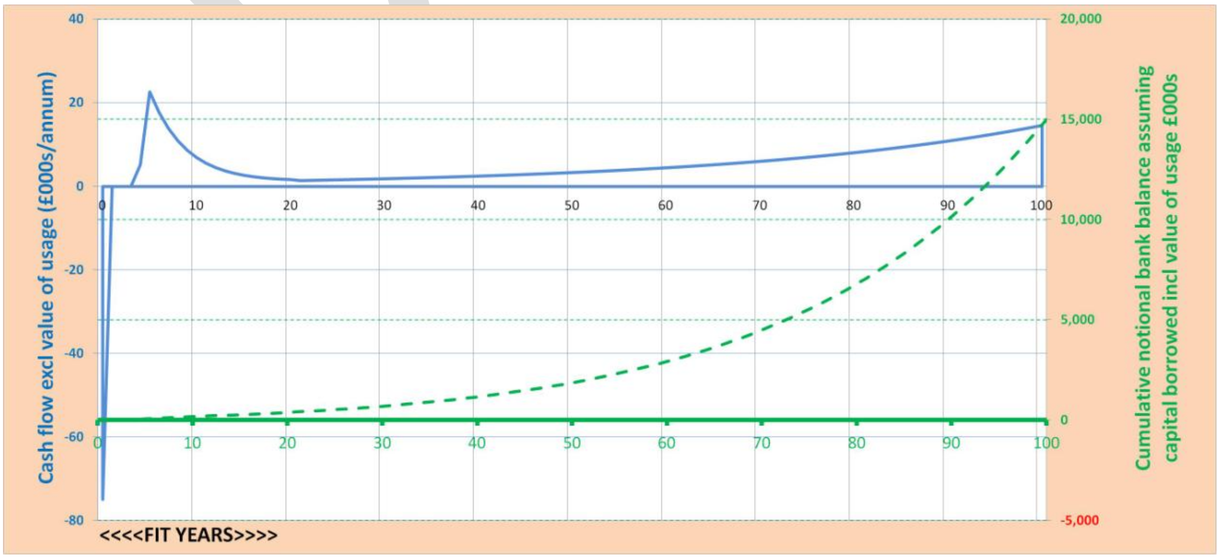
FiT Generation (p/KWh)	20.4	Initial scheme value/ annum (£000s)				Average usage of hydropower (MWh/ annum)	65.38
FiT Export (p/KWh)	4.7					Average estimated export (MWh/ annum)	30.00
Cost of electricity (p/KWh)	10.0	Total	FiT Generation	FiT Deemed or actual export	Usage	Av. Default household usage (MWh/ annum)	4.15
		30.7	19.4	1.4	9.8	Maintenance as proportion of capital	1.0%
	Catchment area (km2)	Rainfall (mm/ annum)	Net head (m)	Mean flow (l/s)	Design flow (l/s)	Design flow as % mean flow	Penstock length (m)
	2.3	1499	40.0	77.0	60.0	78%	560.0
	CO2 savings (tonnes/ annum)	No of average use homes	Average energy (MWh/ annum)	Design Capacity (kW)	Total Capital Cost (£000's)		
	57	23	95.38	17.6	70.0		

Assumes scheme built and operational within 1 year of being awarded FiT eligibility (and FiT rate fixed in initial year)

Internal rate of return	
100 years	110%
20 years (FiT)	110%
10 years	110%
5 years	101%
Capital payback period (years)	4.0
NPV (75 years at 5% discount rate)	£593,629
Excludes tax considerations	

Years from FiT eligibility year	0	1	2	3	4	5
Interest on capital loan/bank balance	7%	7%	7%	7%	7%	7%
RPI and interest on bank balance %	4.0%	3.0%	3.0%	3.0%	3.0%	3.0%
RPI cumulative factor	1.04	1.07	1.10	1.14	1.17	1.21
Year	2013	2014	2015	2016	2017	2018
Capital outlay/ balance £000s	70.0	54.1	36.4	16.8	0.0	0.0
Maintenance costs £000s		0.72	0.74	0.76	0.79	0.81
Value of FiT (generation) £'000s		19.4	20.0	20.6	21.2	21.9
Value of export during and after FiT period £000s		1.4	1.4	1.5	1.5	1.6
Value of usage (assumes RPI) £000s		6.5	6.7	6.9	7.1	7.4
Cash flow excl. value of usage £000s	-74.9	0.0	0.0	0.0	5.2	22.7
Total notional cash flow £000s	-4.9	1.3	6.8	7.2	12.8	30.9
Cumulative notional bank balance assuming capital borrowed incl. value of usage £000s	-4.9	1.3	8.1	15.2	28.0	58.9

Cells in red relate to initial values in FiT year 1 (years 6 to 100 are omitted for convenience)



Low head example cash flow projection

This example is based on a recent scheme estimate by a installer with no reduction in the FiT.

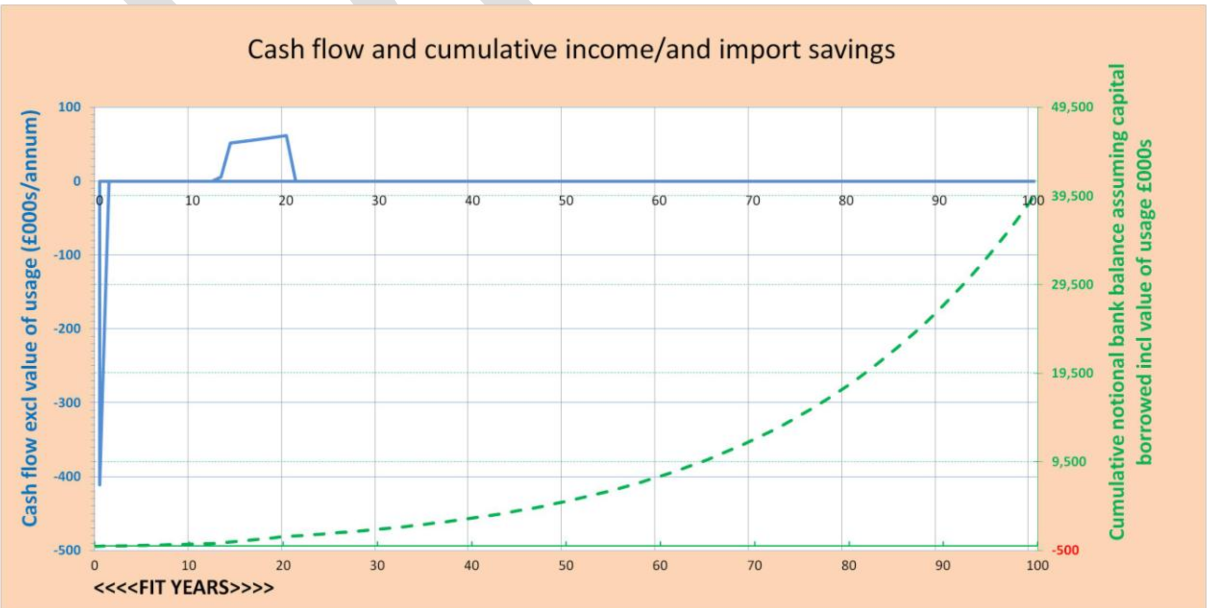
FiT Generation (p/KWh)	20.4	Initial scheme value/ annum (£000s)				Average usage of hydropower (MWh/ annum)	182.50
FiT Export (p/KWh)	4.7					Average estimated export (MWh/ annum)	10.00
Cost of electricity (p/KWh)	10.0	Total	FiT Generation	FiT Deemed or actual export	Usage	Av. Default household usage (MWh/ annum)	4.15
		59.0	39.2	0.5	19.3	Maintenance as proportion of capital	1.5%
	Catchment area (km2)	Rainfall (mm/ annum)	Net head (m)	Mean flow (l/s)	Design flow (l/s)	Design flow as % mean flow	Penstock length (m)
	142.0	1764	2.2	5484.0	3300.0	60%	60.0
	CO_2 savings (tonnes/ annum)	No of average use homes	Average energy (MWh/ annum)	Design Capacity (kW)	Total Capital Cost (£000's)		
	139	56	192.50	44.5	384.0		

Assumes scheme built and operational within 1 year of being awarded FiT eligibility (and FiT rate fixed in initial year)

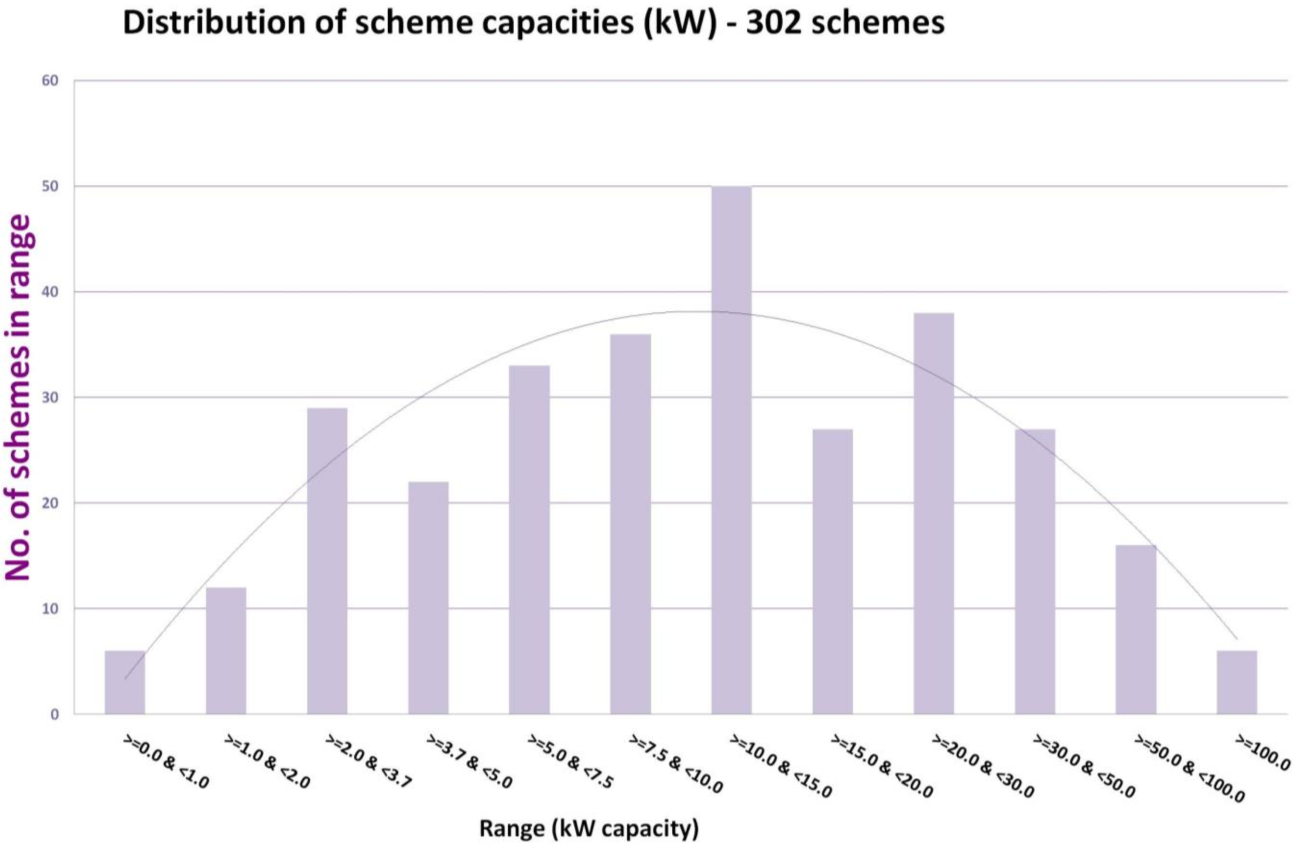
Internal rate of return	
100 years	47%
20 years (FiT)	47%
10 years	44%
5 years	30.64%
Capital payback period (years)	13.0
NPV (75 years at 5% discount rate)	£1,517,763
Excludes tax considerations	

Years from FiT eligibility year	0	1	2	3	4	5
Interest on capital loan/bank balance	7%	7%	7%	7%	7%	7%
RPI and interest on bank balance %	4.0%	3.0%	3.0%	3.0%	3.0%	3.0%
RPI cumulative factor	1.04	1.07	1.10	1.14	1.17	1.21
Year	2013	2014	2015	2016	2017	2018
Capital outlay/ balance £000s	384.0	371.2	356.3	339.1	319.4	297.1
Maintenance costs £000s		4.35	4.48	4.62	4.75	4.90
Value of FiT (generation) £'000s		39.2	40.4	41.6	42.9	44.2
Value of export during and after FiT period £000s		0.5	0.5	0.5	0.5	0.5
Value of usage (assumes RPI) £000s		19.3	19.8	20.4	21.0	21.7
Cash flow excl. value of usage £000s	-410.9	0.0	0.0	0.0	0.0	0.0
Total notional cash flow £000s	-26.9	-9.5	19.2	20.7	21.9	23.2
Cumulative notional bank balance assuming capital borrowed incl. value of usage £000s	-26.9	-9.5	9.7	30.4	52.3	75.5

Cells in red relate to initial values in FiT year 1 (years 6 to 100 are omitted for convenience)



Appendix III sample analysis of over 300 potential and actual schemes (mainly in Scotland) - capacities



Appendix IV sample analysis of potential and actual schemes (mainly in Scotland) – costs and performance

Number of schemes:	302
TOTAL design capacity of schemes(kW)	5714
TOTAL realisable power of schemes (kW)	3260
Total realisable energy of schemes to date (MWh/annum)	28464
TOTAL initial value of schemes from FiT (£000s/annum - 3% index linked)	6955
TOTAL Value of schemes from use of "free" electricity (£000s/annum)	469
TOTAL Carbon offset of schemes (tonnes CO_2/annum)	16898
TOTAL Cost of schemes (£000s)	25893
Average scheme cost (£000s)*	85.7
Average scheme design capacity (kW)	18.9
Average scheme realisable energy (MWh/Annum)	94.3
Average scheme lifetime (75 years) energy (GWh)	7.1
Average scheme capital cost of lifetime energy (pence/kWh - current prices)*	2.6
Average Load factor (% average energy per annum÷total energy if scheme were able to run at full capacity all year)	59%

*basic materials, components, and labour costs with 25% uplift for business overheads, and a further 25% profit uplift in the supply chain

Realisable energy of schemes to date (MWh/annum)	
28,464	
(approx 6,900 homes)	
Scheme average	94 (MWh/annum)
	56 (tonnes CO2/annum)
energy/ power (kWh/kW)	5.0

This analysis is compiled from surveys of potential and actual schemes by the author, and incorporated in a model for evaluating performance and costs. The surveys have been used to inform potential scheme owners of their possibilities for hydropower. Most of the surveys are based on 1:25000 ordnance survey maps and on publicly available hydrological data – costs of hydropower scheme components have been taken from industry (2010 prices) and inflated by 33% to reach current prices.

Appendix V micro hydro schemes commissioned under FiT scheme

The tables below summarises new schemes with capacities <100kW DNC reported by Ofgem as commissioned between April 2010 and December 2012

No. commissioned 1/4/2010 - 31/12/2010	21
Capacity (kW)	507
No. commissioned 2011	55
Capacity (kW)	1630
No. commissioned 2012	44
Capacity (kW)	1436
Total commissioned Apr 2010 - Dec 2012	**120**
Capacity (kW)	**3574**