Due diligence assessment - Halton Lune Hydro

Quality Control Page

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Whilst every effort has been made to ensure the information and figures provided in this document are accurate please be aware that this is influenced by the completeness and accuracy of data or information provided by the client. My Green Investment actively works with the client to minimise inaccuracies however at times this can be unavoidable. If My Green Investment is aware of issues with quality of data or assumptions are made, this is highlighted within the relevant sections.

The financial analysis provided in the recommendations are indicative, and based on the information provided. Generation and therefore returns are dependent on a large number of variables including head, flow and efficiency of equipment. Further information on the efficiencies of the turbines should be corroborated with the manufacturer.

This review is time-limited and it is expected that recommendations made within the document will go through the client's own validation and approval process prior to implementation. My Green Investment places the utmost importance on ensuring recommendations are robust and fit for purpose, however pertinent information may not have been available during the review. My Green Investment reserves the right to amend the findings and recommendations in this document should more accurate data or information become available. The client and readers hold sole responsibility for the decisions and actions it takes using information contained within this document.

Executive summary

This report has been written in response to a request from Halton Lune Hydro (HLH) to undertake Due Diligence for a hydroelectric installation development at Forge Bank weir. The scheme currently holds all necessary consents and planning and is currently undertaking a successful community share offer with the intention of raising all the capital cost of the scheme from the community. The construction has now started with the turbine house dug out and concrete about to be poured. Halton Lune Hydro has commissioned this study to verify the scheme is likely to meet its potential expectations and returns to be made to the community.

Halton Lune Hydro is a special purpose vehicle, set up to build, own and operate the Hydroelectric turbine installation at the Forge Bank weir. Halton Lune Hydro is a 'Society for the Benefit of the Community (Bencom), which is a form of Industrial Provident Society, registration number: 32233R.
It is expected that the first stage project cost will be in the region of £1,250,000 of which £276,000 ex VAT has already been European/Defra grant funded, with the balance from community shares paid back over 20 years. Virtually all upfront costs are then covered for the second turbine to be installed one year after the first has been commissioned at an estimated £240,000 cost, covered with a second community share issue.

The aim of this study is to give potential investors in the Halton Lune Hydro scheme, a detailed appraisal of the accuracy and validity of the data used. This study covers:

- flow data and hydro resource assessment;
- technology and construction suitability;
- potential energy and income assessment;
- project risk and sensitivity.

Potential investors could have an interest in investing in this scheme for a myriad of reasons. These include;

- supporting the development of an asset that will give them ongoing dividends for 20 years;
- offsetting carbon emissions through the generation of green electricity;
- ensuring a green source of electricity generation;
- potential to develop a community benefit funding pot.

A summary of the risks evaluated in this report can be seen in Table 1. It can be seen that most areas of risk have been assigned a 'Low' category, further explanation is detailed within the report.

Table 1– Risk assessment summary

Area of risk	Risk
Energy yield and flow data analysis	LOW
Technology	LOW
Construction and development	LOW
Project (consents)	LOW
Financial assessment	LOW
Sensitivity assessment	
Electricity price	LOW
Reduced energy generation	MEDIUM
Increased project costs	MEDIUM
Operation and maintenance	LOW
FIT changes	LOW

The main purpose of this modelling is to ensure that community investors receive relative comfort that they will secure the expected return on their investment. This assessment has shown that the hydro scheme is a valid investment opportunity. Technically the assessment has shown the work by Halton Lune Hydro to be robust.

HLH have forecast that the community investors will receive a 5% annual return on their investment. Using data defined in Scenario 1, seen in Table 2 it has also been calculated that investors can expect to receive project returns, with an IRR of 4.91%, but with the inclusion of Enterprise Investment Scheme tax relief, this increases to 8.09%.

Table 2 – Expected total annual generation

Flow data derived from:	Potential Energy Generation, kWh, with efficiency at design flow			Corresponding Annual abstraction, m^3
	T1 @ 83%	T2 @ 73% with increased shut down	Total	
FDC averaged over 1992-2012	672,100	281,000	953,100	249,765,120

In the worst case scenarios outlined in this report, there may be years when share interest is held back, although overall, the project can be expected to pay the above returns across the life of the project. For investors benefiting from the Enterprise Investment Scheme tax relief, this return will come directly from HMRC.

However, due to the many variables that determine the potential energy generated from a Hydro installation, the figures can only be used as indicative. This report has considered 40 years of flow data, however, with the unpredictability of climate change, forecasting future rainfall and flow cannot be wholly based on historical norms. This report has determined that even under extreme modelled conditions, where the scheme generates significantly less than anticipated, the project should still provide a return that is comparable to other Micro hydro projects.

Contents

1 Background

1.1 Introduction

Forge Bank weir is situated at grid reference SD 51279 64762 on the River Lune, 3.5 miles North East of Lancaster. The Lune is tidal only below Skerton in Lancaster, 3.5kms from Forge Bank weir (as the crow flies). According to the Environment Agency, the River Lune headwaters rise from Shap Fell and the Pennines. The catchment basin has a mixed geology with Carboniferous Limestone; Silurian shales; Millstone Grit and Coal Measures. There is agriculture in the valleys and grassland with peat moss in the highest areas.

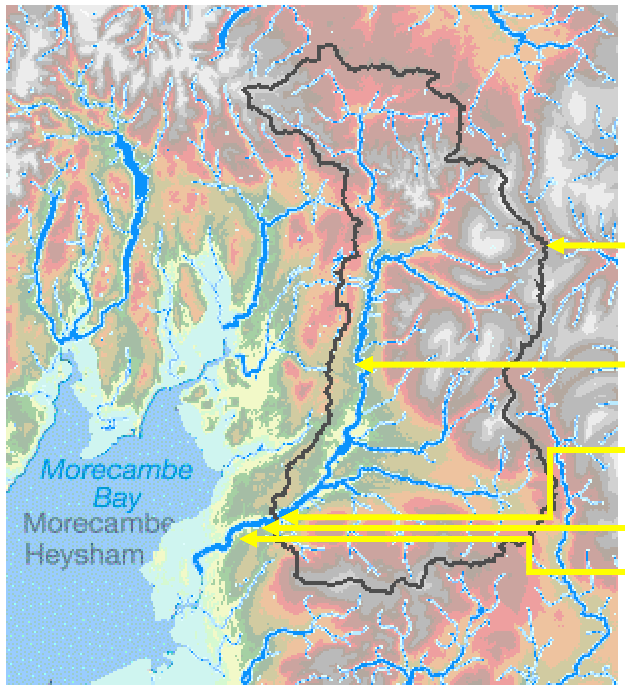


Figure 1 - Catchment area for the River Lune at Caton (CEH)

Figure 2 - Forge Bank weir (Google earth)

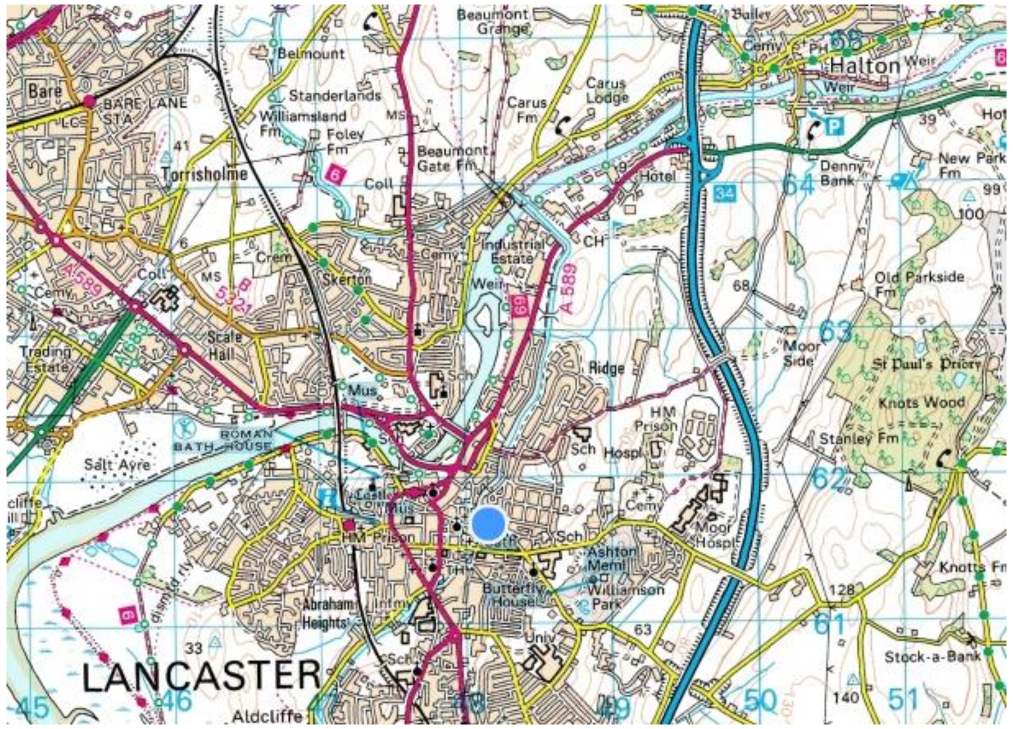
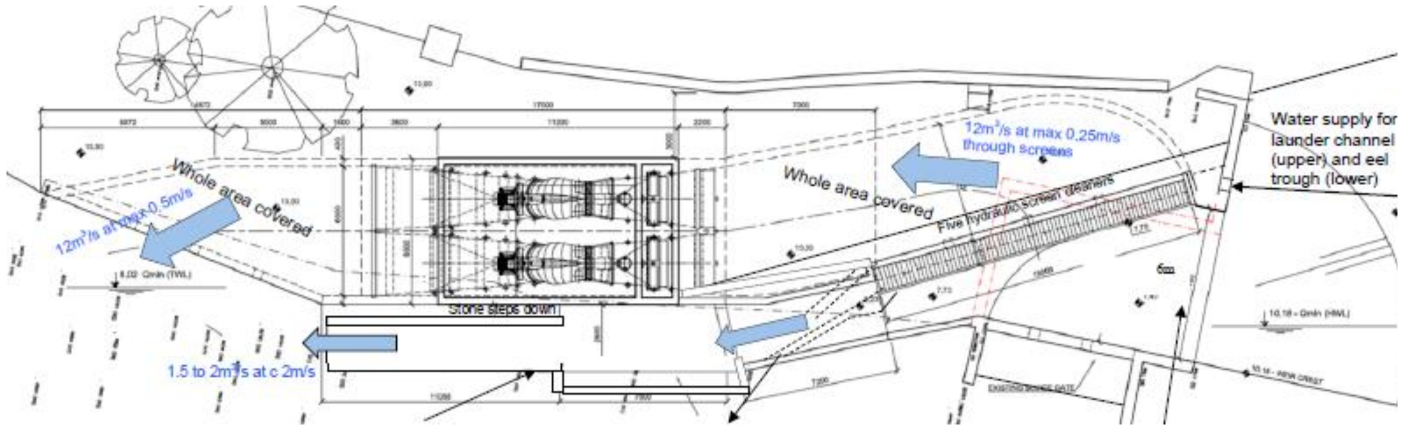


Figure 3 - Town of Lancaster (Bing maps)

Forge Bank weir, seen in Figure 2 and Figure 3, is situated to the North East of Lancaster. The weir is of concrete construction and is 110m in length.

1.2 Proposed scheme

The proposed installation will be sited on the northern bank of the River Lune. The installation area has no environmental or historical designations, according to [Magic map](), although according to the EA, this part of the River Lune is a biological heritage site. The configuration can be seen in figure 4. It will consist of two parallel, axial flow propeller turbines, using a combined abstracted flow of 12m^3/sec. The pair will have a combined installed capacity of 200kW. At this time, only the first turbine with a rated capacity of 100kW will be installed, with the second turbine being dropped into the allocated place within the subsequent 2 years.



Fish pass Eel pass

Figure 4 - Proposed Design (Hydrohrom)

The scheme will be installed alongside a new fish pass and include provisions to assist eel passage moving both up and down stream. The powerhouse will sit directly on top of the turbines; 7m x 8m, and will be a natural stone clad building with a natural stale roof.

1.3 Report objectives

The scope of this report is to undertake due diligence of the Forge Bank weir scheme developed by Halton Lune Hydro to give confidence to potential investors as to whether the scheme warrants investment. Halton Lune Hydro Ltd are progressing with the development as a community owned social enterprise using finance raised through community share issue, alongside grant funding for environmental essentials.

1.4 Due Diligence methodology

My Green Investment have broken down and evaluated each area of the project which poses a risk to the development and the sustained success of the project. We have assigned the results of each of the areas evaluated for the due diligence assessment, a traffic light colour code, according to the risk identified. The traffic light system highlights easily which areas need further risk mitigation. This traffic light system is based on the following methodology.

	High risk Significant potential impact on financial viability of scheme Risk will be difficult or costly to mitigate Requires further investigation immediately
	Medium risk Marginal potential impact on the financial viability of the scheme Risk can be minimised by simple solutions or changes May require further investigation during development of the project
	Low risk Minimal or zero impact on the financial viability of the scheme No further assessment required

1.5 Documentation details

As part of this review the documentation referred to in Table 3 has been checked. Green denotes documents are completed and signed off, amber implies they are nearly complete and red would necessitate unready status.

Table 3 - Documentation

Documentation	Status	Action
Permissions		
Planning permission	Granted	Implement approval conditions
Abstraction license	Granted	Implement approval conditions
Land lease and way leaves	Granted	Access consent to HLH by LCH registered to be registered with Land Registry
Finance		
Shareholder investment – as per share offer document	Disclosed	
Contingency secured	Undisclosed	Verify where this will be held
Civils	Ongoing	HLH as Main Contractor
Turbine supplier - Supply contract	Complete	
Turbine supplier - service contract	Awaiting completion	It is likely that servicing contracts will be agreed locally
Revenue		
PPA	Awaiting completion	Agreed with Lancaster Cohousing, who own the Grid Connection
FIT Pre-accreditation	Confirmed	Agreed by Ofem
Private wire agreement	Complete	
O&M		
Confirmation and summary of Insurance offer	Disclosed	Package agreed
O&M schedule	Awaiting confirmation	An O&M management plan should be detailed prior to commissioning
Potential ongoing costs summary	Disclosed	HLH have set out potential administration and operation costs

2 Due diligence assessment

2.1 Energy generation and yield analysis

Energy can be extracted from falling water and harnessed to provide mechanical or electrical power. The theoretical amount of energy available from any given site is directly proportional to two factors: the actual volume of water passing the site (the flow) and the height through which the water falls at the site (the head). Therefore these variables are key in understanding the energy generation potential at any installation site.

	Low risk • The predicted energy generation estimations calculated by Halton Lune Hydro and those engaged to independently check the figures, appear to be robust. Prediction of flow is robust.

2.1.1 Flow data and Hydro resource assessment

The nearest gauging station to the weir is approximately 1.7 kms upstream (as the crow flies) at Caton. The typical river level range for this location is between 0.28 metres and 3.20 metres. The highest river level recorded at this location is 7.06 metres and the highest recent river level was 5.83 metres reached on 5/1/2011.

Although the gauged data at Caton doesn't give exactly accurate flow rates at Forge bank weir, it allows us to understand the pattern of flow of the River Lune at that point. Figure 5 and Figure 6 are graphs of the River Lune gauging station data at Caton, from CEH, UK National River Flow Archive from the years 1992-2012. Figure 5 shows us that, although there are spikes in the gauged annual river flow (black line), there is a good constant base flow. The spikes suggest that there is relatively fast run off into the river, post precipitation, due to the surrounding geology. However, Figure 6, shows a relatively flat flow duration curve, which indicates that there is predominantly a steady constant flow as opposed to a flash prone flow, where River levels rise and drop fast. A steady constant flow is much more likely to result in a more productive hydro generation plant.

Figure 6 highlights the averaged seasonal difference in river flow from the years 1992-2012, with the winter flow far exceeding the summer flow. According to the Centre for Hydrology, in the UK, rainfall is on average, fairly evenly distributed throughout the year with a tendency towards an autumn/winter maximum, however, seasonal variations in temperature and sunshine ensures that evaporation losses are heavily concentrated in the summer half-year (April-September). This results in a marked seasonality on river flows with maximum flows normally in the winter and minimum flows normally occurring in the summer or autumn.

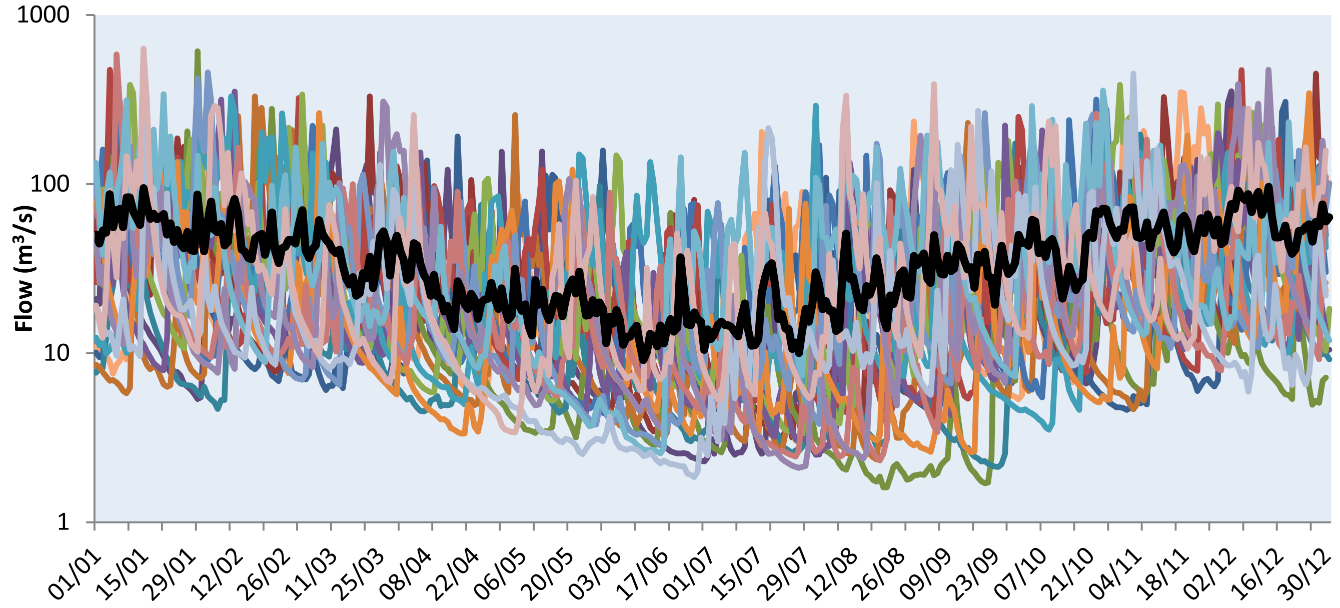


Figure 5 - Gauged annual flow, 1992-2012 (Black line depicts the average annual flow)

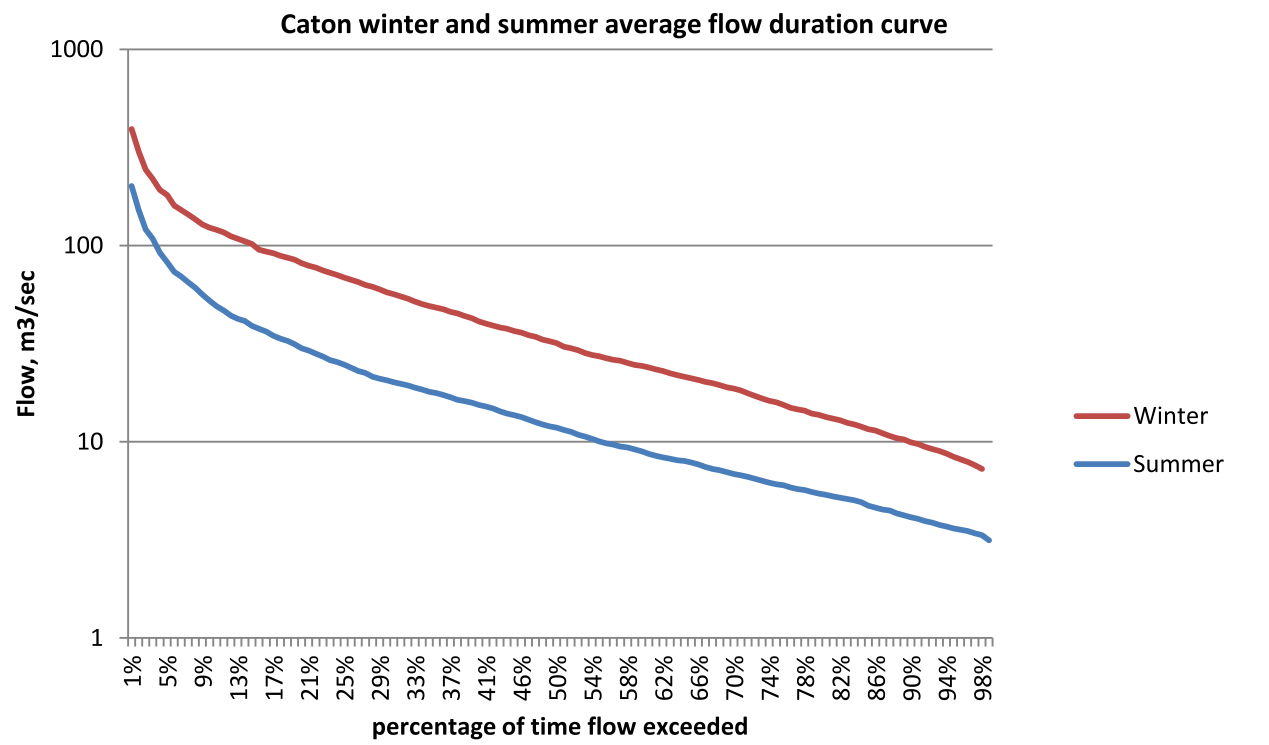


Figure 6 - Flow duration curve for average summer and winter flows 1992-20

2.1.2 Abstraction

Table 4 – Summary of flow data statistics, between 1959-2012 (CEH)

Base flow index	0.32
Mean flow	36.235m^3/s
95% exceedence, Q_{95}	3.233 m^3/s
70% exceedence, Q_{70}	10.3 m^3/s
50% exceedence, Q_{50}	17.6 m^3/s
10% exceedence, Q_{10}	88.54 m^3/s

The Environment Agency (EA) has granted Halton Lune Hydro Ltd a licence, Serial number: NW/072/0526/002 to abstract a maximum of 12m^3/sec and 249,765,120m^3 per year from the River. The Environment Agency usually allow an abstraction amount (on or around a weir) of the mean flow x 1.3. In this case that would have enabled an abstraction of 47m^3/s. However, this is a sensitive site for migratory fish therefore the EA have requested a significantly reduced volume of water to be abstracted.

The licence requires HLH to ensure that a hands off flow of 4.74m^3/sec flow is maintained in the river upstream of the weir. This is slightly higher than the normal Environment Agency requirement, which is usually Q_{95}. Halton Lune Hydro must ensure that 1.5 m^3/sec flows through the fish pass at all times. There are also many monitoring tasks required to be undertaken by HLH to keep within their licence agreement. The licence expires on 31st March 2029, where upon it is expected that HLH will reapply for a renewal of this licence.

Energy generation has been calculated using 12m^3/sec, when available, but a decreasing flow rate through the turbines has been modelled as the River flow rate decreases, ensuring the Hands Off Flow (HOF) is always maintained. It is expected that Turbine 1 will outperform Turbine 2 due to better positioning. Therefore, it is likely that turbine 1 will take slightly more of the water abstracted and perform at a higher load factor (percentage of time operational during the year) than turbine 2. As mentioned in the paragraph above, as a significantly reduced flow has been requested for abstraction, this means both turbines will have a larger load factor than most schemes calculated at approximately 59%. Calculated separately, Turbine 1 has a potential load factor of 73% and Turbine 2 of 45%.

Table 5 - Abstraction parameters

Terms of abstraction	Scheme design
Maximum abstraction = 12m^3/s	Scheme design maximum flow rate = 12m^3/s
Total daily abstraction = 1,036,800m^3/ day	Maximum designed total daily abstraction = 1,036,800m^3/ day
Total yearly abstraction = 249,765,120m^3 / year	Predicated yearly abstraction = 249,203,779 m^3 / year

It can be seen from Table 5 that the design flow of the scheme, based on the flow duration curve, falls within the EA's total abstraction parameters. The EA requires that monitoring is undertaken to ensure that these parameters will not be breached. The predicted yearly abstraction is taken from the Flow data from the HLH FDC and modelled to understand how much water will be used by the turbines. However, looking at individual years, where there has been higher than average data and the potential to generate more energy, in line with the 12m^3/m abstraction limit, HLH may be required to add addition downtime so as not to fall outside of the yearly abstraction amount.

2.1.3 Flow data at Forge bank

As seen in Figure 1 Forge Bank weir is downstream from Caton gauging station. This means that there is an increased catchment area and potentially a higher natural river flow at Forge bank weir. However, the additional catchment area is so marginal that an increase in flow rate has not been determined from Caton to Forge Bank weir. There is also one abstraction, which is now mostly redundant. This is the Lune Wyre United Utilities extraction which is now silted up and only runs periodically to clear any natural build up of methane. If water is likely to be abstracted at this point in severe drought conditions, this would be at a time when flow would be too low for the hydro to be operational..

The Flow Duration Curve in Figure 7 has been taken from averaged data from the Caton gauging station from the years including 1992 to 2012.

Potential risks for depleted flow through turbine:

- Climate change brings the risk of more extreme weather patterns, including prolonged drought and flooding.
- Potential for future increased abstraction upstream.
- The ability of scheme design to attain the design flow rate.
- Obstruction to intake caused by buildup of trash on trash rack.

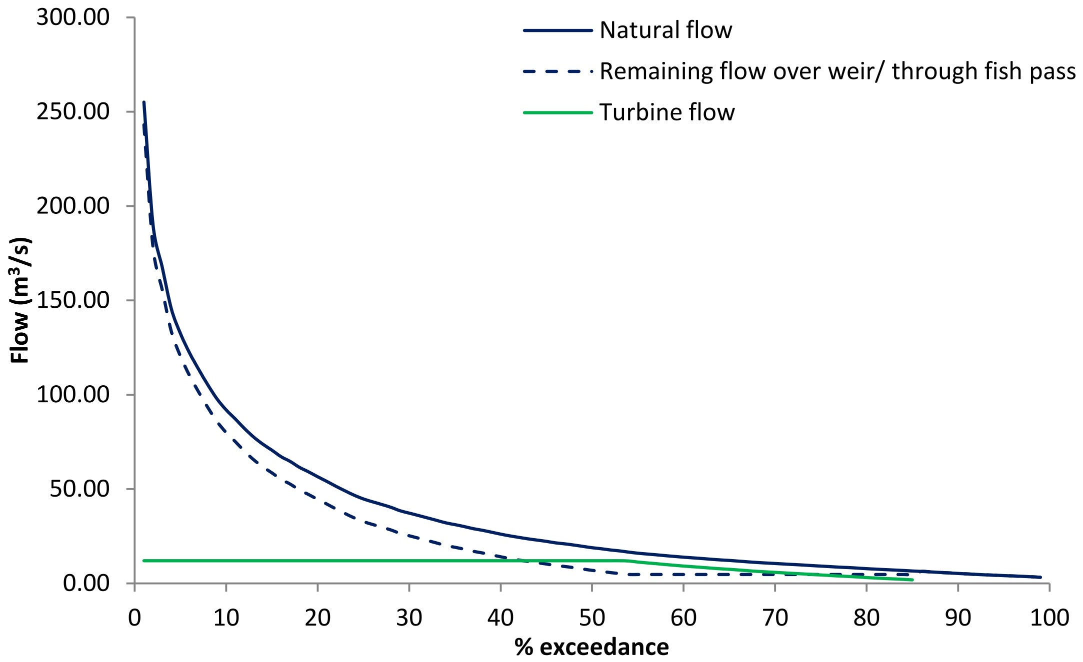


Figure 7 – flow duration curve at Caton weir, averaged data from 1992-2012

2.1.4 Assessment of head data, including variations of net head with variable flow

The gross head is the maximum available vertical fall in the water from the upstream level, at the intake, and the downstream water level at the discharge point. An important factor on low head schemes is that the gross head is not constant, but varies according to the river flow.

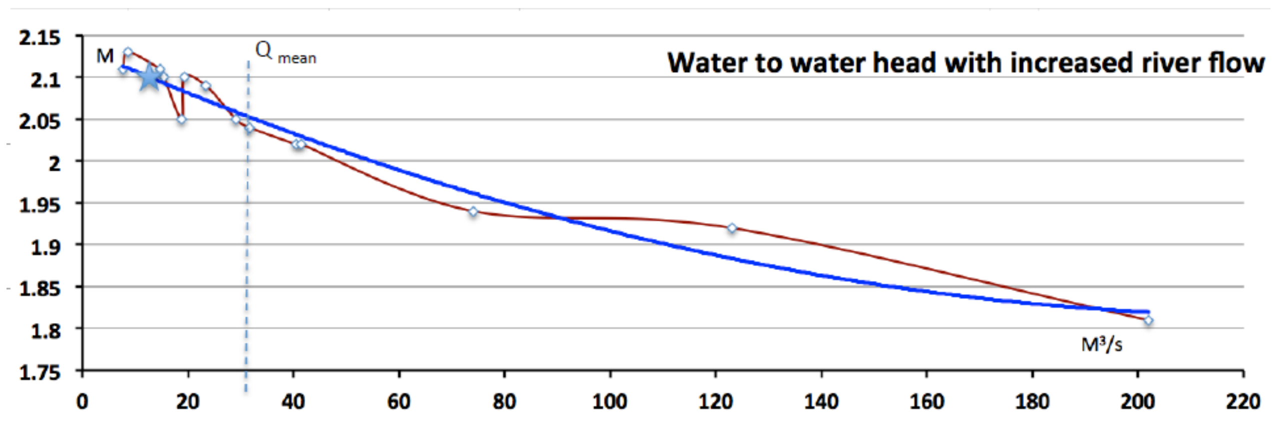


Figure 8 – Variation of head with flow

As can be seen in Figure 8, the head reduces as the flow increases. These measurements were undertaken by HLH above and below the weir with approximately 3m between the measuring points. These head losses have been used to calculate the total energy generation. However, reduction in head losses across the screen has been supplied and can only be deemed to be accurately calculated by the screen supplier. Head loss and the subsequent reduction in energy generation has been an issue for some hydro generation projects. Therefore modelling for these additional losses have been undertaken in the revenue prediction. However, as the project has twin turbines, the first turbine can operate at a greater design flow to compensate for this loss of head and Turbine 2, receiving the lower FITs, will have the reduced output.

Potential risks do remain, including:

- Head losses from the intake and outfall screens are greater than calculated;
- Head loss from the intake channel is greater than calculated;
- Introducing a new permanent structure within the river could cause additional deposition. This could have an impact on reducing head, through siltation, above and below the turbines.
- The weir is not of sound construction and collapses. [Surveyed by United Utilities last year and maintenance due next year]

2.1.5 Efficiency

Calculating the overall efficiency of the scheme is paramount to estimating energy generation. However, efficiency is determined by the many components of the scheme and is variable according to the river flow and the load on the turbine.

Figure 9 depicts the efficiencies of different turbines at percentage of design flow. It should be noted that efficiency curves are usually produced by the manufacturers and there is a dearth of independent empirical evidence to corroborate these efficiencies. Therefore this graph should be viewed and used with caution, however, it indicates that the efficiency gradually drops away as the flow reduces from the design flow.

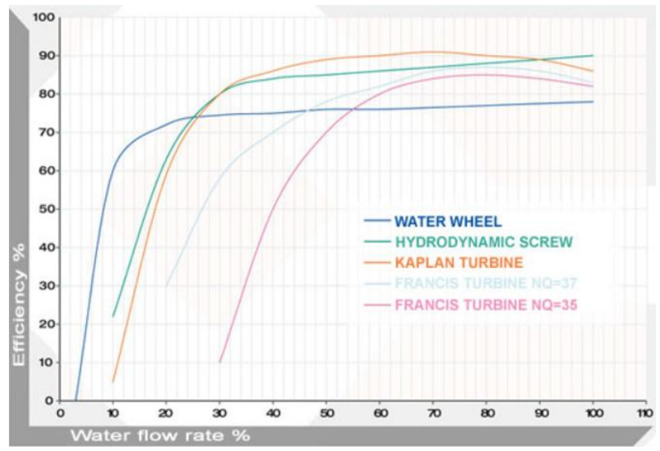


Figure 9 - Turbine efficiencies (WAM group)

It can be seen that the Kaplan has as high efficiency compared to other turbines and only begins to reduce its efficiency when the flow through the turbine is at 30% of its design flow.

Other efficiency losses will come from, generator, inverter and transmission losses. To provide a range of scenarios in the financial modelling, differing overall efficiencies have been used to calculate averaged annual generation over the 40 years of data used. This ensures a range of scenarios are understood. With turbine 1 having an exceptional high load factor, this will ensure it is operating at its design flow for a large proportion of its time and therefore maximising efficiencies. It is likely that Turbine 2 will be operating at its design flow for less time and may have reduced efficiencies compared to Turbine 1, however, as this is receiving the lower FIT, this will have less financial impact on the project.

2.2 Prediction of energy yield

	Medium risk • The greatest risk is that increased downtime will be required, to ensure the annual abstraction is not surpassed. • Unscheduled downtime could reduce energy yield but it is felt this is low risk with proper O&M procedures in place and a twin turbine design whereby staged maintenance can be undertaken. • Increases in severe weather caused by climate change could cause flooding and/or droughts and could impact on the scheme with loss of generation in both instances. • Entrainment of elver in May and June during low water flows, could reduce water flows, although consulting specialists Fishtek consider, based on their analysis, it would appear that the risk of elvers bing drawn into the turbine flow at this site, to be low. HLH say that they would undertake maintenance during these low flow conditions, rather than install 2mm seasonal screening, should the EA call for such measures. • Head losses through siltation could occur • Head losses through debris on the fish screens could reduce energy generation, although the screens are self clearing and as the installation is 200ms from Lancaster co-housing, it is likely the screens will be checked daily.

2.2.1 Effect of efficiencies on energy yield

Gauging station data from Caton weir has been evaluated for a 40 year period, between the years 1959 to 2012. This excludes the years 1977 and 1978 as there is no available data for these years.

Figure 10 shows the likely energy generation from the proposed scheme using this historical data, based on an average water to wire efficiency of 73% and an average net head of 1.9m. The black trend line shows a relatively flat average of 985.7MWh generated per annum.

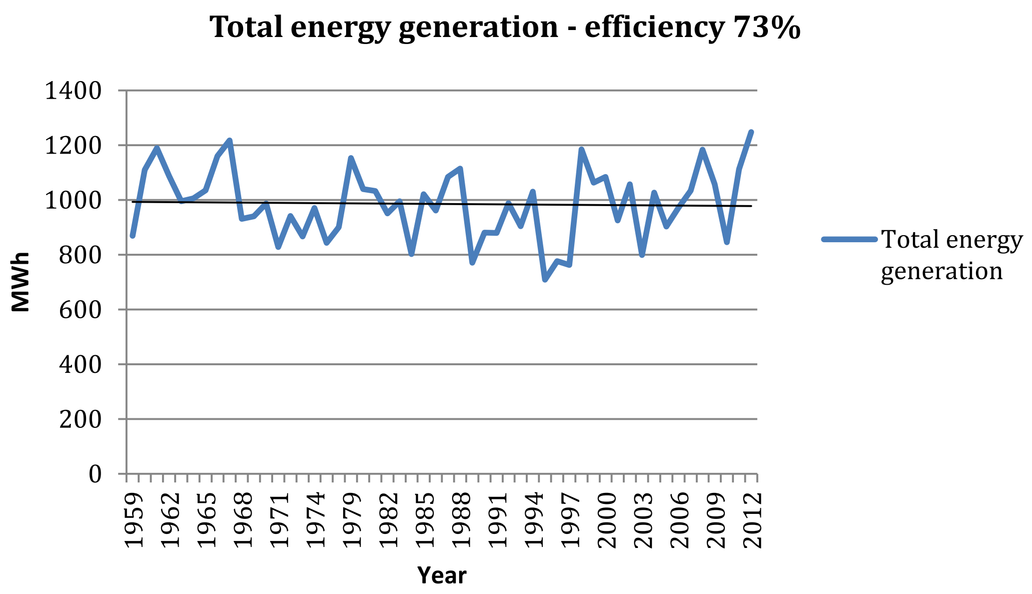


Figure 10 - Likely yearly energy generation from proposed scheme using historical data 1959-2012

However, if an efficiency of 83% is used, then the average generation of the 40 years is raised to 1,120.7MWhs.

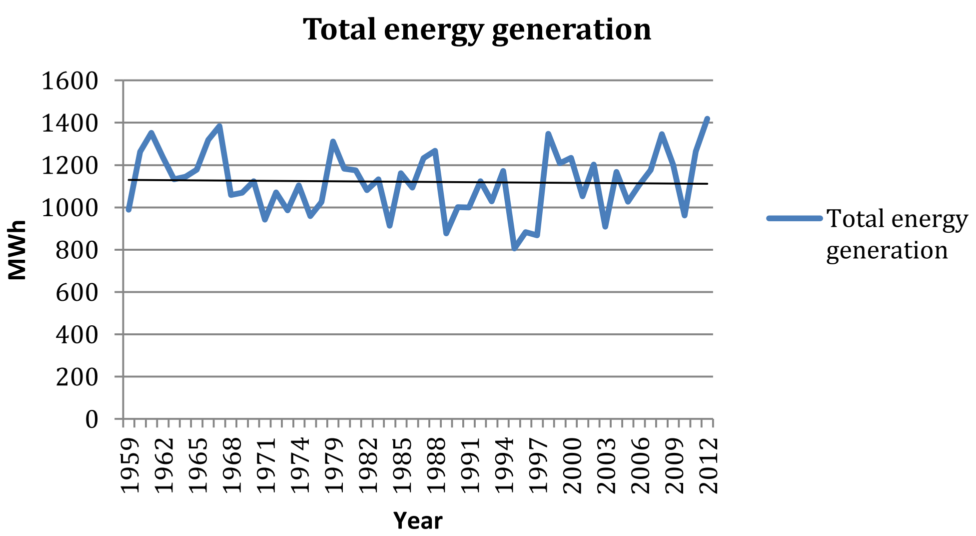


Figure 11 - Likely yearly energy generation from proposed scheme using historical data 1959-2012

These graphs give some indication of the yearly energy generation fluctuations that a hydro installation can be expected to produce. Table 6 shows the average generation using the 40 year data set, alongside the maximum and minimum year's generation, with a net head of 1.9m and overall efficiencies of 73% and 83%.

Table 6 - Average, Maximum and minimum between 1959 and 2009

	Energy Generation, kWh using data from 1959-2012		Corresponding Annual abstraction, m^3
	Scheme efficiency 73%	Scheme efficiency 83%	
Average	985,659	1,120,681	260,785,683
Maximum year	1,247,993	1,418,951	330,194,016
Minimum year	709,094	806,230	187,612,070

It can be seen in Table 6 that the average and maximum energy generations have abstracted more than the EA's annual allowance of 249,203,779$m^{3.}$ If the installation fails to perform at an efficiency of 73% and river flows only meet the driest year in the last 40, then this could have significant impact on the profitability of the scheme.

2.2.2 Variable head and efficiency

Using the net head measurements varying with differing flow rates and also reducing efficiency in line with a reduction away from the design flow, we can achieve a more accurate potential energy output.

With an averaged flow duration curve derived from the 1992-2012 data and also the data from the HLH Flow duration curve, alongside variable head and efficiencies, the potential energy generation figures can be calculated and are seen in Table 7.

Table 7 – Average energy generation, using variable head and efficiency

Flow data derived from:	Potential Energy Generation, kWh, with efficiency at design flow		Corresponding Annual abstraction, m^3
	73%	83%	
FDC averaged over 1992-2012	915,234	1,046,180	264,722,645
Data from HLH FDC	872,596	996,676	256,863,874

However, it can seen that these generation figures rely on an abstraction amount greater than the EA annual allowance. Therefore, it is likely that turbine 2 would be required to shut down prior to the maximum annual abstraction being reached. This gives us the energy generation depicted in Table 11. Due to the limit on annual abstraction, it is likely that 994,711kWh will be the maximum annual generation amount. This could be greater if head losses are minimised and efficiencies maximised.

Table 8 – Average energy generation, using variable head and efficiency

Flow data derived from:	Potential Energy Generation, kWh, with efficiency at design flow		Corresponding Annual abstraction, m^3
	73%	83%	
FDC averaged over 1992-2012	871,632	994,711	249,765,120
Data from HLH FDC	844,483	963,573	249,765,120

It has been calculated that Turbine 1 is expected to meet about 62% of the overall energy generation. With the additional factors discussed, it is likely that Turbine 1 will perform at a more optimal efficiency than Turbine 2, which may also be subject to increased downtime to ensure the maximum yearly abstraction is not surpassed. Therefore it is thought that the most likely output of the turbines will be as stated in Table 9.

Table 9 – Average energy generation, using variable head and efficiency

Flow data derived from:	Potential Energy Generation, kWh, with efficiency at design flow			Corresponding Annual abstraction, m^3
	T1 @ 83%	T2 @ 73% with increased shut down	Total	
FDC averaged over 1992-2012	672,100	281,000	953,100	249,765,120

Therefore the calculation of 953,100kWh has been used as a baseline in the financial modelling. This compares slightly less favourably than the HLH calculations, where it has been calculated that a total generation of both Turbine 1 and 2 will deliver approximately 1006MWhs per annum.

2.2.3 Downtime for operation and maintenance, scheduled and unscheduled

It is usual to model downtime as 2%, per annum in the generation and revenue calculations. However, due to evidence from other schemes, this is considered to be very low and to further analyse risk, modelling with increased downtime has been evaluated, as this could have significant impact on generation if the scheme experiences an unforeseen technical issue. A 2% downtime represents 7 days throughout the year, although downtime for regular maintenance can be timed to coincide with low flows when the turbine will not be operational, unscheduled maintenance could occur any time. Drawing on knowledge of operational projects, unexpected downtime has occurred and these unforeseen circumstances and their impact should be considered and modelled. An understanding of the timeframes for obtaining spare parts should be factored into an operation and maintenance schedule. The design lifetime of most hydro turbines can be 40 years, although this could be exceeded with adequate maintenance.

2.2.4 Twin turbine design

One of the benefits of having a twin turbine scheme ensures that even if one turbine has downtime, the other will continue to be operational. This has the benefit of reducing the risk of lost generation. But there is a negative impact on cost flow, due to 2^{nd} turbine having reduced efficiency. 2^{nd} turbine will underperform.

2.2.5 Energy yield conclusion

According to the Centre for Ecology and Hydrology, characteristically, the river systems in the UK are short, shallow and subject to considerable man-made disturbance. River flows are especially sensitive to changes resulting from climatic variation or the effects of manmade factors including further abstraction, land use change and urbanisation. As hydro schemes are a long term investment over 20-40 years, these effects cannot be prophesised, quantified or mitigated against and should be considered as a subjective risk.
Potential risk to energy generation:

- The risk of drought and flood is increasingly prevalent and this longer term risk has been modeled by evaluating the effect of reduced flow on the energy yield and correlated revenue to gain insight into the effect it could pose on the project margins.
- Increased downtime due to technical issues.
- Siltation or deposition causing reduction in head and/or flow.

An energy generation model has scrutinised the outputs by modelling the flow rate data, available head data, projected downtime and system efficiencies and then stress testing by exaggerating these variables. This gives an understanding of how the installation would perform in 'sub-optimal' conditions, such as drought, flooding, reduced efficiencies, increased downtime due to part failure and siltation. This impact on energy generation and the financial integrity of the project is further discussed in the financial appraisal section.

2.3 Technology and construction appraisal

	Low risk • Halton Lune Hydro have the necessary skill set; • Construction and development risks are viewed as low risk; • The technology chosen and sizing appear robust.

2.3.1 Technology selection

An initial feasibility study was undertaken to determine the most appropriate turbine for the site. Without further feasibility work the opportunity for installing a different turbine or scheme configuration cannot be fully assessed and appraised. Therefore on the information provided, it is suggested that this is a suitable technology for installation at the site.

HydroHrom are providing the turbine and generator. They have provided equipment and have installed several other schemes extensively in Europe and now increasingly in the UK. Risks remain around equipment failure, however insurance of the scheme should mitigate against this risk.

2.3.2 Has the scheme been sized correctly with a suitable turbine?

My Green Investment has confidence that Halton Lune Hydro has designed the scheme with suitably sized turbines. However, power output is determined by the flow and head across the turbines, therefore if these variables are consistently lower than the design speciation then there will be underperformance. The proposed installation will allow Turbine 1, which is optimally positioned, to be the main turbine, performing at a high capacity factor. As the two turbines are to be installed separately to ensure both are banded in the <100kW FIT band. Vigilance should be that they do not have a power output above 100kW and as a consequence be moved into the lower FIT band by Ofgem.

2.3.3 Construction

A detailed construction method has been set out by the developer and approved by the planners. A contingency of 10% of the total build costs has been allowed. The digging out is now finished and concrete is about to be poured. As the work is being carried out alongside, not in the river, this reduces many of the risks around constructing a hydro installation. The biggest risk of flooding during the construction phase has been mitigated, with a "bagged out" in-river barrier, which has already withstood high and unseasonal river flows.

2.3.4 Project team

Halton Lune Hydro team is comprised of:

- John Blowes
- Alan Denham
- Brian Jefferson
- Kevin Frea
- Huw Johnson
- Jonathan Sear
- Alison Cahn

John Blowes is the Project Manager and is supported by Construction Manager Alan Denham. Both are Chartered engineers with many years of relevant experience between them.

2.4 Project risk and sensitivity analysis

Halton Lune Hydro has obtained the necessary consents for the special purpose vehicle (SPV), Halton Lune Hydro ltd, to construct a hydroelectric scheme at Forge Bank weir. However, there are conditions to these consents and careful monitoring must be undertaken to ensure these conditions are met.

	Low risk • Consents and licenses are in place as seen in Table 3 • Land lease and Way leaves are in place • Insurance is in place • A Riparian Rights Fishery Agreement is in place

2.4.1 Planning

Halton Lune Hydro have secured planning permission Application No. : 12/00140/FUL. As construction has begun, the licence is not under threat of expiring.
Approval of the scheme was granted subject to the following conditions:

- Bat measures and otter survey carried out prior to development with a mind to protecting their routes, movements and habitats Scheme for bats.
- Tree protection
- All building worked fenced at all times
- Fish pass approved, save for minor detail
- Method statement approval
- Any building regulations approvals sought

2.4.2 Abstraction licence

The abstraction licence gives permission for Halton Lune Hydro to abstract $12m^3/s$ for the use of hydroelectric generation through the use of two axial flow turbines.
The licence requires that a 10mm coarse/trash screen is at the entrance of the screw turbine and an agency-approved fish pass structure is placed at a location approved by the Environment Agency (EA). The licence requires that no less than $1.5m^3/$ s flow though the fish pass at all times. This license is eligible until 2029, however if Halton Lune Hydro Ltd are found to be in breach at any time of this license or the EA see fit to rescind the license then it can be withdrawn, prohibiting the scheme to abstract any flow from the River Lune. With the expected monitoring to be undertaken by the operators of the scheme, it is unlikely to breach these conditions.

2.4.3 Impoundment licence

Impoundment licence Serial number: NW/072/0526/003 was granted on 16th December 2013, to undertake modifications to the existing weir structure to construct a Lariner type fish pass, fish counter and fish trap structure according to the drawings submitted by HLH. There are multiple conditions attached to the impoundment licence in relation to fish monitoring to be undertaken by HLH.

2.4.4 Land leases and Way leave agreements,

United Utilities are the land owner of the site, under Title Number LAN114770 and LAN129457. United Utilities have agreed and signed a land lease in October 2013 for the period of 25 years, granting Halton Lune Hydro tenancy. The lease restricts disposition. The lease allows the option for renewal of the tenancy for a further 25 years, on the same terms except for the rent.
The land lease annual rental is commercially confidential and therefore cannot be stated in this report, however, the amount has been inputted into the business case model. The lease agreement began on October 2013 with an annual 'construction' rent and upon the 'commissioning date' when the generator starts to export electricity, the 'base rate' period begins, this is increased at the 5 year review date in line with the Index of retail prices. This base rent is increased in year 10 and then in line with RPI at the 5 year review.
The tenant or landlord can break the lease with 6 months notice.

There is a clause in the tenancy agreement that states that the 'Plant and fixtures' shall be removed at the end of the contractual term. This entails a 'decommissioning bond' which will begin to accumulate within 30 days of commissioning.

HLH and Lancaster Co-Housing have a collaboration agreement in place, signed 3/2/14 which will ***'continue to be valid until both parties agree, unless the hydro equipment becomes permanently inoperable. The Contract may be terminated on an months notice by either party in the event of serious non compliance by the other party, after demonstrated attempts to rectify the non compliance have failed'.***

In the Collaborative agreement LCH grants HLH access and easement via normal roads and tracks to HLH and their authorised agents, for the purposes of construction, commissioning, operation and maintenance of the hydro installation at all times, provided that HLH give due consideration to residents and visitors in the locality to minimise disturbance. The access route will be registered with Land Registry, once all financial aspects have been agreed and in particular, prior to conclusion of Construction.

2.4.5 PPA and private wire

Halton Lune Hydro will sell the electricity generated, via a private wire to Lancaster Co-housing with whom they will have a Power Purchase Agreement whereby according to the collaborative agreement, they will charge ***'at a rate mid way between the LCH National Grid buy and sell, with fixed and variable costs taken into account'***.

The excess electricity not consumed by Lancaster co-housing will go to the grid and be sold by LCH and HLH will charge LCH exactly the same amount as LCH receive for the electricity exported. A PPA between LCH and a purchaser of the electricity is yet to be defined.

For the purposes of this model, the export price to the LCH has been taken as 7.82p/kWh and electricity exported to the grid from LCH has been assumed to be the export tariff of 4.54p/kWh. The Retail Price index has been assumed to be 3.1%.

HLH will claim FITs on all electricity generated at the hydro installation, as metered by the hydro FITs meter.
It has been assumed that LCH will use 20% of the electricity generated.

2.4.6 Operation and maintenance

Halton Lune Hydro will be responsible for the ongoing Operation and maintenance of the hydro scheme. An effective O&M regime is paramount to ensure generation potential is maximised and a weekly and annual O&M regime should be drawn up prior to commissioning. Close observation of the automatic trash rack clearance should be undertaken in the first months of operation, to ensure it is clearing debris adequately and not causing reduced head or flow through the turbine.

2.4.7 Insurance

It will be essential to ensure that any scheme is suitably insured to include protection against downtime losses for generation and FIT income. Insurance for equipment in transit during development is also advised.
Halton Lune Hydro Ltd, is currently insured under a 'Construction all risks' policy for £1,200,000, valid until January 2015. United Utilities state that the turbine installation and premises should be insured for a minimum of £5,000,000.

2.4.8 Health, Safety and Environment

It will also be essential to ensure that appropriate Health, Safety and Environment regimes are documented during any works and for the ongoing site O&M. Health and safety protocols should be in place once the scheme is operational, prior to allowing visitors within the turbine house.

2.4.9 Flooding

Flood Defence Consent were approved, as below:

- Consent, number: 2012-NWL-288, for a proposed retaining wall was issued on 5/12/12.
- Consent, number: 2012-NWL-289, for proposed electricity cable was issued on 5/12/12.
- Consent, number: 2012-NWL-290, for the proposed fish pass was issued on 5/12/12.
- Consent, number: 2012-NWL-291, proposed Hydro building & fish screen bay was issued on 5/12/12.

A Flood risk assessment has been carried out and calculations undertaken to determine the minimum height, above ordnance datum (AOD) for the turbine house floor. A worst case flood has been determined to give an AOD of 12.52m, therefore the doorsill level has been recommended at 12.9m AOD.

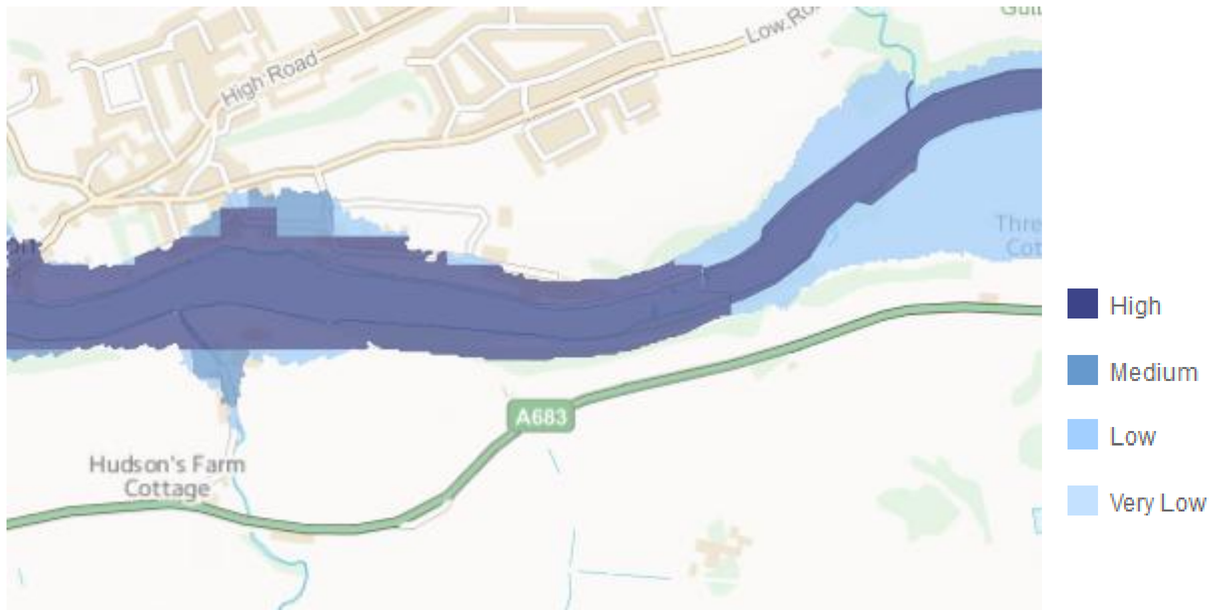


Figure 12 – Environment Agency risk of flooding map

The scheme is built within the active floodplain as seen in Figure 12. However, design of the turbine house has been determined to withstand a 100 year flood, with the additional impact of potential for increased river levels due to climate change.

2.5 Sensitivity analysis

The financial assessment undertaken has been based on the model prepared by My Green Investment. It is also important to stress test the financial model through a sensitivity analysis to understand potential risk to financial returns. Areas of risk are considered below.

2.5.1 Electricity market changes

No sensitivity was undertaken to changes to the electricity market. This was due to the fact the electricity price has been agreed through a PPA and it is thought unlikely that the price of electricity will drop significantly in the next 20 years. In the event of a change in circumstance, the export tariff is guaranteed by the FIT regime (and index linked).

Current market projections see electricity prices rising, so it is therefore not anticipated that the electricity price will have a detrimental effect on the scheme.

	Low risk • Income from electricity sales should be viewed as minimal impact on the financial viability of the scheme

2.5.2 Increased project costs

If the project overruns the contingency and there are insufficient funds to complete the build, this could be a risk to the project. This risk is minimised by the fact that the project has already broken ground and as yet, no issues, except a longer period to take out bedrock. If this issue was to befall the project, it is likely that further finance could be raised on the scheme due to its overall profitability. However there are inate ongoing risks with civil engineering projects that require this to be classed as medium risk.

	Medium risk • Contractor experience should detect any issues that may arise mid-build • There is considered to be sufficient contingency allowance

2.5.3 Increased operational and management costs

This is a risk, however, hydro turbines are tried and tested pieces of plant and it is unlikely that increased O&M costs will impinge upon the returns for community investors.

	Low risk • Minimal or zero impact on the financial viability of the scheme • A detailed O&M schedule should be completed prior to commissioning

2.5.4 FIT

The FIT hydro tariff rates for Hydro can be seen in Table 10. Degression of the FIT took place at the end of March 2014 and the rates were reduced, as per the second column. However, Halton Lune Hydro pre-accredited their first turbine prior to the FIT degression cut off date on the 31st December 2013 and have been successful in their application, therefore they will receive 20.76p/kWh of energy they generate. This rises with the retail price index over a 20 year period.

Halton Lune Hydro will only develop the second turbine when the first is operational to ensure they fall within the >15kW-100kW FIT band. This will ensure they are maximising their generation revenue.

Table 10 – Feed in tariff rates for hydro

FIT	<31/4/2014	>31/4/2014
>15-100kW	20.76	19.20
>100kW-500kW	16.41	15.18

Turbine 2 will be considered an extension to the existing scheme. According to Ofgem: in their Extensions to FIT accredited installations 2.79.

"Where a FIT installation is extended using the same technology type, the extension is assessed as a separate Eligible Installation. If successfully accredited, the extension will be assigned a separate eligibility period and separate tariff code based on the aggregate TIC of both the extension and existing FIT installation. In this situation, the eligibility date and the eligibility period of the extension will be based on the commissioning date of the extension. The original installation's eligibility date, tariff, and eligibility period will not be affected. Both installations will, however, share the same FIT ID31on the Central FIT Register (CFR) -the register on which all installation details are stored"

It is therefore likely that Turbine 2 will receive £0.1518 tariff for the installation. However, this will have been reduced by degression potentially by 10%. This rate will however have been raised according to the RPI. It has been assumed that Turbine 2 will benefit from a rate of £ 0.1407.

	Low risk • Changes to the FIT may reduce the commercial viability of the scheme but if pre-accreditation is agreed then this will mitigate against this risk

2.6 Financial appraisal

2.6.1 Community investment in Halton Lune Hydro Ltd

HLH wish to secure community investment into the Halton Lune Hydro ltd, the special purpose vehicle set up to build, own and operate the hydroelectric turbine installation at Forge bank weir.
It is expected that the total project cost for the first turbine will be in the region of £1,250,000. The scheme is expected to be financed solely through the community share issue after having received grant funding worth £273,000 ex VAT.

HLH have issued a share offer document, in which they propose that community members investing in the scheme will be in line to receive a 5% annual return on their money in addition to their investment returned. This return will come off the gross profit of the project.

The second turbine, to be installed one year after the first becomes operational will benefit from all upfront costs having been covered, this will be the subject to a separate share offer requiring in the order of £240,000.

2.6.2 Financial model

A financial model detailing the construction costs, revenue, profit and costs has been built and has been subjected to stress testing according to different potential risks to the generation and revenue of the scheme. Assumptions made within the model are:

- FIT rate of £0.2067, the FIT tariff that HLH are likely to receive on confirmation that their pre-accreditation was successful;
- FIT rate for Turbine 2 of £0.1407
- A power purchase agreement with LCH of 7.82p/kWh, with 20% of the exported electricity being sold directly to LCH;
- An export tariff for electricity not used by LCH as 4.64p/kWh;
- Annual inflation of 3.1% has been used throughout the model for the increase in FITs and the sale of the electricity through the PPA. Whilst it is widely accepted that electricity prices could rise beyond this, a prudency has been observed.
- IRR calculations do not include the net asset value.

2.6.3 Financial returns

As the financial success of the project is largely proportionate to the turbines generating energy, significant sensitivity has been undertaken around the energy yields over the project lifetime. Differing scenarios have been modelled to understand the impact on the returns for the investors.

2.6.1 Scenarios modelled

Scenario 1 - This is the baseline giving an average generation of 953MWh over the 20 year lifetime of the scheme and can be considered to be a good indicator of the potential of the scheme. This is based on a flow duration curve averaged over 20 years of data from 1992-2012, turbine 1 variable efficiency of 83% at design flow and 73% for Turbine flow, a variable net head in line with the HLH measurements taken and shut down of Turbine 2 in line with EA maximum yearly abstraction.

Scenario 2 - A random scenario based over 20 years has been built up by mixing the extreme minimum and maximum generation amounts from the historic data, with the addition of reduced efficiency, reduced head and increased downtime for various years. Table 11 considers the fluctuation of variables and provides an indicator of the impacts of risks on the scheme.
It should be noted that 10% downtime equates to 36.5 days across both turbines in one year.

Table 11 - Generation modelled on averaged flow data over 50 years

				% Downtime efficiency 83%			% Downtime efficiency 73%		
Flow data	Net head	Efficiency 83%	Efficiency 73%	2%	6%	10%	2%	6%	10%
Baseline - FDC 1992-2012	Variable with flow rate	995	872	975	935	895	854	819	784
HLH FDC	Variable with flow rate	963	844	944	906	867	828	794	760
Average years (1959-2012)	1.9	1121	986	1098	1053	1009	966	927	887
Max year 2012	1.9	1419	1248	1391	1334	1277	1223	1173	1123
Min year 1995	1.9	806	709	790	758	726	695	667	638

As previously discussed and stated in Table 8 the EA maximum annual abstraction would not allow the scheme to generate substantial more than 994MWh. Therefore the projected 20 year scenario, as seen in Table 12 caps any potential energy generation figures at 994MWhs. The resulting average, (taking in extreme risks to the project) gives an average annual energy generation amount as 866MWh.

Table 12 - Scenario 4

Year	Flow for year	Head, m	Efficiency, %	Downtime, %	Energy Generation, MWh
1	Min	1.9	73	6	667
2	Min	1.9	73	10	638
3	Baseline	Variable	83	2	975
4	Average	1.9	83	2	994
5	HLH	Variable	73	6	794
6	Max	1.9	83	10	994
7	Min	1.9	83	6	758
8	Average	1.9	83	6	994
9	Baseline	Variable	73	0	872
10	Min	1.9	73	6	667
11	Average	1.9	83	6	994

12	Baseline	Variable	83	6	935
13	HLH	Variable	83	2	944
14	Min	1.9	83	0	806
15	HLH	Variable	73	2	828
16	Baseline	Variable	83	0	994
17	Average	1.9	83	10	994
18	HLH	Variable	73	0	844
19	Average	1.9	73	2	966
20	Min	1.9	73	6	667
Total					**866**

Table 13 – Summary of scenario potential energy generation

Scenario	Total potential energy generation, MWh
Scenario 1	953
Scenario 2	866

2.6.2 Likely annual revenue from the 2 scenarios

Table 14 – Summary of revenue variables

Turbine 1	FIT, p/kWh	20.76
	LCH, p/kWh	7.82
	Grid, p/kWh	4.64
Turbine 2	FIT, p/kWh	14.072
	LCH, p/kWh	0
	Grid, p/kWh	4.7328

Table 15 – Summary of revenue

		Scenario 1	Scenario 2
Turbine 1	Output, kWh	672,087	610,835
	FIT, £	139,525	126,809
	Export LCH, £	10,511	9,553
	% to LCH	20%	20%
	Export Grid, £	24,948	22,674
	% to grid	80%	80%
	Total income, £	174,984	159,037
Turbine 2	Output, kWh	280,945	255,340
	FIT, £	39,534	35,931
	Export LCH	-	-
	% to LCH	0.0	0
	Export Grid, £	13,297	12,085
	% to grid	100%	100%
	Total income T2, £	52,831	48,016
Total	Total output, kWh	953,032	866,176
	Total income T1&T2, £	227,815	207,053

2.6.1 Modelled expected returns for the 2 scenarios

The main purpose of this modelling is to ensure that community investors receive relative comfort that they will secure the expected return on their investment. It is forecast that the community investors will receive a 5% annual return on their investment. Using Scenario 1, it has also been calculated that investors can expect to receive project returns with an IRR of 4.91%, but with the inclusion of Enterprise Investment Scheme tax relief, this increases to 8.09%.

If the worst case, scenario 2, happens then there may be years when dividends are held back, although overall, the project can be expected to pay the above returns across the life of the project. As has been seen across this report, hydro generation is expectant on a number of variables and investors should be aware of the yearly fluctuations of energy generation in line with variability of nature.

2.6.2 Comparison with similar Hydro schemes

These returns can be compared to other similar hydro schemes with smaller turbines. These have considerably less return available. The higher returns available for Halton Lune Hydro are due to the much lower £/kWh installation cost.

Table 16 - Comparative costs of other hydro schemes

	78kW	50kW	50kW
Capital cost	£753,000	£415,000	£474,000
Type of scheme	Low head - screw	Low head - screw	Low head - screw
IRR 20yr	3.8%	3.7%	4.1%
NPV 20yr	-£174,830	-£181,000	-£171,000
Status	Under consideration	Operating	Operating

2.6.3 Conclusion

Compared to the projected returns of other projects seen in Table 16 this project offers a far greater return. There are also even greater potential returns for investors who can capitalise on the Enterprise Investment Scheme tax allowances.

	Low risk • It is likely that the project will generate enough energy to bring in a revenue that will provide the forecasted projected returns on investment.

3 Conclusion

This assessment has shown that the hydro scheme is a valid investment opportunity. The assessment has shown the technical approach of Halton Lune Hydro to be robust. However, with this investment, the rate of return figures can only be used as indicative, due to the many variables discussed. This report has determined that even under extreme modelled conditions, where the scheme generates significantly less than anticipated, the project should still provide a return that is comparable to other smaller hydro projects.

The table of risks below highlight the existing risks to the project.

All areas of risk have been classified as low after this Due Diligence exercise. However, risk is subjective and investors should form their own conclusions from the information provided within this report.

Table 17– Risk assessment summary

Area of risk	Risk
Energy yield and flow data analysis	LOW
Technology	LOW
Construction and development	LOW
Project (consents)	LOW
Financial assessment	LOW
Sensitivity assessment	
Electricity price	LOW
Reduced energy generation	MEDIUM
Increased project costs	MEDIUM
Operation and maintenance	LOW
FIT changes	LOW

Table 18 – Table of risks

Risks	
For Project	For Halton Lune Hydro
HLH fails to deliver on Turbine 2:	HLH have designed the scheme for 2 turbines. The profitability of the scheme will require the second turbine is installed and commission within the next 2 years.
Pre-accreditation is not granted and Turbine 1 will only be allocated 19.20p/kWh	The Director's have been in constant contact with Ofgem and there is expectation that this will not be the case.
Down rating of Turbine 1	Ofgem will down grade the FIT band if Turbine 1 performs at over 100kW. Care should be taken that this turbine only performs within its permitted installed capacity.
Annual Abstraction maximum	Operation must be within the EA permitted abstraction limits.
Weather: this is always an unknown and the appropriate timing of works and commissioning date are the best mitigation tools. Project construction should be undertaken in the spring/summer with enough contingency built in for errors and kit faults at commissioning	Delays caused during construction results in the first revenues being delayed.
Third party delays: Sufficient clauses for the contractors to meet the specified timelines with penalty clauses for non-compliance should be contracted. Regular clear communication is key. Turbine and generator manufacture delays – these could be ordered in advance with a deposit paid.	There is the risk that the turbine or other plant equipment manufacturers go into liquidation taking project capital with them. Halton Lune Hydro would use well established and long standing equipment manufacturers to alleviate this risk.
Commodity prices: Price fluctuations could give rise to increased construction costs. However, if prices can be fixed at order this risk dissolves.	If the project is put on hold this commodity price fluctuation could prove to be a risk.
Exchange rate fluctuation: from receiving the quote and ordering of the turbine and generator to making payment.	The contingency should be sufficient to cover these fluctuations.
Weir damage or collapse	HLH must ensure they have sufficient insurance to cover this eventuality.

Glossary

Due diligence	Is an investigation of a business, person or project prior to signing an investment contract, undertaken with a certain standard of care. Finance providers will typically undertake their own due diligence.
EBITDA (earnings before interest, taxes, depreciation, & amortization)	the EBITDA of a company gives an indication on the operational profitability of the business, i.e. how much profit does it make with its present assets and its operations on the products it produces and sells, taking into account possible provisions that need to be made.
Equity dividends	is the annual cash flow that an equity investor receives.
Fixed term return	is a guaranteed minimum return at the end of an agreed investment term.
Index-linked	is the coupling of payments such as the Feed-in Tariff and Renewable Heat Incentive to the retail price index in order to ensure the income from them is in line with inflation.
Internal rate of return (IRR)	is used to measure and compare the profitability of investments.
Net present value	is a standard method for using the time value of money to appraise long-term projects. it measures the excess or shortfall of cash flows, in present value terms. It compares the present value of money today to the present value of money in future, taking inflation and returns into account
Special Purpose Vehicle/Entity - SPV/SPE	a corporation can use such a vehicle to finance a large project without putting the entire firm at financial risk.