

**MONITORING OF SUCCESSFUL
RENEWABLES OBLIGATION SMALL
HYDRO PROJECTS**

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Contractor

Caledonian Energy Management Ltd

The work described in this report was carried out under contract as part of the New and Renewable Energy Programme, managed by the Energy Technology Support Unit (ETSU) on behalf of the Department of Trade and Industry. The views and judgements expressed in this report are those of the contractor and do not necessarily reflect those of ETSU or the Department of Trade and Industry.

EXECUTIVE SUMMARY

To date 146 small hydro projects have been awarded contracts under the Non-Fossil Fuel and Scottish Renewables Obligations. Of these only 38% have actually achieved commissioning. This is of concern to the DTI and hence it was decided to examine typical successful projects to obtain lessons which could be of assistance to developers in bringing forward previously unsuccessful projects. This report provides a summary of this work.

The work was carried out during 1999 by Caledonian Energy Management Ltd as part of the New and Renewable Energy Programme managed by the Energy Technology Support Unit (“ETSU”) on behalf of the Department of Trade and Industry (“DTI”).

Three projects having very different characteristics were selected for the study. These were a low head project at Barton Lock on the Manchester Ship Canal, a medium head project on the River Rannoch in the West Highlands of Scotland and a multi-turbine scheme based in the Elan Valley in mid Wales. Each project was successful in different aspects of the development process and as a result a number of clear lessons were learned which could be of use to future developers. The principal features which contributed to the success of some or all of the study projects are discussed in Chapter 3 of the report and summarised as follows:

- The use of experienced hydro professionals during the feasibility and planning stages.
- Careful assessment of likely environmental impacts and extensive consultation with interested parties during the planning consent application.
- The use of standard forms of contract in procurement.
- The combined use of experienced supervision by hydro professionals and cost-effective local contractors during construction.
- Diligent operation assisted by state-of-the-art telemetry systems.

Following the analysis of the specific features of the study projects, further consideration was given to more general good practice in small hydro development. Chapter 4 of the report provides a set of general guidelines which it is intended will be of assistance to a typical small hydro developer of limited experience.

These guidelines should be viewed as a checklist for each stage of the development but are not intended to replace the advice which is available from an experienced hydro engineer.

Finally, a factual description of each project is presented in the appendices to the report. It is recommended that these appendices are read initially to appraise the reader with the background to the discussion and recommendations presented in the main body of the report.

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1. GENERAL

1.1 Introduction

This report describes the work carried out by Caledonian Energy Management Ltd under contract to ETSU for the Department of Trade and Industry as part of the new and Renewable Energy Programme.

It is a source of concern that many small hydro projects which have secured contracts under the various renewables obligations have so far failed to achieve commissioning.

The aim of the work was to obtain useful information which could assist future developments by examining three successful renewables obligation small hydro projects of different types and determining the reasons for the success of each.

It is hoped that the information provided herein may be of assistance to developers of hitherto unsuccessful projects and future renewables obligation schemes.

1.2 Report Format

During the course of our brief, we examined three small hydro projects which had been successful in achieving commissioning. The information obtained was then considered and the lessons which could be learned from these developments were formulated. We then compiled a set of bullet point guidelines for developers which are intended to form a 'check-list' at each development stage.

The report provided herein comprises two parts, being the main body and the Appendices. The main body of the report considers the lessons learned from the study projects (Chapter 3) and provides the guidelines for developers (Chapter 4). This information is set out in a logical sequence conforming to the normal project development activities.

The appendices provide individual case studies for each of the projects examined. These case studies are intended as a factual account of the progress of each development. Comment as to the specific lessons learned is given at the end of each appendix.

2. PROJECT CASE STUDIES

2.1 Selection of Projects

In order to obtain data for assessment, it was considered appropriate to select three projects with disparate characteristics. The projects selected for study were as follows:

- A 715kW medium head scheme developed on the River Rannoch in the West Highlands of Scotland by a private estate owner;
- A 660kW low head scheme developed at Barton Lock on the Manchester Ship Canal by a regional electricity company;
- A multi-site scheme developed in the Elan Valley in mid Wales by a major water company.

It was hoped that the variations in scheme type and developer would provide a reasonably complete picture as to the issues affecting the most common type of hydropower development in the United Kingdom at the present time.

2.2 Information Gathering

Information was sought in respect of each scheme from the developer, the developer's consultants, the planning and environmental authorities and the regional electricity company.

Standardised questionnaires were compiled and sent to each party for completion. The data was then analysed and further discussions were held with relevant parties.

2.3 Summary of Findings

From the research work it is clear that all three projects examined were successful in so far as they are all now commissioned, producing power and contributing to UK targets for the reduction in greenhouse gas emissions.

Within each project there are areas which could however be considered more successful than others. The intention of the report is to draw out those successful elements in order that lessons can be learned, rather than dwelling on any negative aspects. It was however considered appropriate to highlight some of the less positive points in relation to the operational performance of two of the schemes in order that this experience can also be of benefit to future developers.

A summary of each of the projects is as follows:

River Rannoch

- Highly successful during the feasibility, planning, design and procurement phases.
- Slight cost and time over-runs during construction not inconsistent with the use of economic local contractors.

- Operational performance less successful due to problems with equipment reliability.
- Overall, the scheme has met the developers objectives and is viewed as a successful model for future developments of a similar nature.

Elan Valley

- Again very successful during the feasibility, planning, design and procurement phases.
- Significant cost savings achieved due to simultaneous procurement of multiple schemes.
- Minor delays during installation of plant due to interface between civil works and plant design.
- Production targets have been achieved during the operational phase.
- Again the scheme has met the developers objectives and provides a good model for the development of multi generator schemes.

Barton Lock

- Very successful during all stages from inception to commissioning.
- A good example of how technical innovation and construction experience can allow development of schemes under technically challenging conditions.
- Less successful during the operational phase due to a combination of low water flows and technical problems.

As noted above, each scheme provides lessons with respect to the various phases of a hydro project development. These lessons are discussed in further detail in Chapter 3 below. A summary of key recommendations drawn from these lessons is presented in Chapter 4.

3. LESSONS LEARNED FROM DEVELOPMENTS

3.1 Discussion

From the case studies it has been possible to draw together the positive or successful features of the three projects during the various stages of development. Often we find common factors contributing to success and accordingly, it is suggested that lessons can be learned from the projects studied which can be applied to future developments.

Each stage in the development of a small hydro-electric project is discussed below and particular lessons are highlighted as appropriate.

3.2 Specific Lessons

3.2.1 Inception and Feasibility Stage

A fundamental pre-requisite for a successful small hydro project is a good site. Whilst this statement may seem almost flippant, many sites which may appear to have good potential may in fact have critical flaws. Examples of such critical flaws include un-cooperative landowners, low electrical network capacity, unforeseen environmental constraints, etc. It was noted however that for each of the projects studied, the feasibility assessment was staged in such a way as to identify critical flaws at an early stage, thus reducing risk expenditure to the developer.

KEY POINT

Ensure that you or your advisors consider all aspects of the development site at a very early stage in order to identify critical flaws.

Remember that barriers to development may be non-technical.

In Scotland, particular attention should be paid to ownership of the water rights to the affected waterway.

It was also found that in each of the study projects, the initial feasibility review and subsequent study was carried out by experienced professional advisors. It is considered that this laid the foundation for a successful project in each case.

All too often, the development of a hydro project is viewed in simplistic terms by inexperienced developers due to the fact that the technology is relatively easy to understand. The reality is that understanding the technology represents only a very small proportion of the overall project scope. A clear understanding of environmental, legal, commercial and operational issues is also vital to achieve a successful project in the long run.

Whilst professional advisors may appear expensive, it is undoubtedly the case that they will save a developer money in the long run by ensuring the success of the project.

KEY POINT

Good professional advice is invaluable throughout the project.

A good advisor will not charge more for any stage than is necessary and should always stage his advice in order to minimise risk exposure.

A good advisor will also ensure that the technical, environmental, commercial and legal aspects of a project are considered and progressed in parallel.

There is no point in spending £20,000 on a detailed technical study and application for a power purchase agreement if you cannot secure the necessary water rights!

3.2.2 Obtaining a Power Purchase Agreement

It will be appreciated that the ability to sell electricity on commercially acceptable terms is the key to obtaining funding for any small hydro project. Electricity is normally sold to an electricity company or industrial user under a power purchase agreement (“PPA”). Of the projects studied, the Barton Lock and Elan Valley schemes secured contracts with the Non-Fossil Purchasing Agency under the terms of the first and third Non-Fossil Fuel Obligations respectively. The River Rannoch scheme secured a contract with the two Scottish electricity companies under the terms of the first Scottish Renewables Obligation. The security offered by the renewables obligation contracts is considered to have been a crucial factor in the success of the three projects. In particular the guaranteed price for a fixed duration, combined with the financial strength of the purchaser (effectively a sovereign contract) provided a high level of reassurance as to the security of the income stream. This in turn allowed the positive investment and lending decisions to be taken.

KEY POINT

A power purchase agreement must be ‘bankable’

This means that the buyer must be of sound financial standing, the price and duration of contract must be guaranteed.

Developers considering PPAs outwith the provisions of a renewables obligation should take detailed advice and consult with their potential financiers before committing to such a contract.

It is worth noting however that the owners of the River Rannoch project gave serious consideration to proceeding with the project on the basis of a power purchase agreement negotiated with a local industrial electricity user. This however was discounted due to the perceived commercial risk which would have made raising finance difficult. It is also noted that the price bid for the River Rannoch project was one of the lowest in the hydro band of SRO1. In retrospect, given the slight cost over-runs on the project and the subsequent operating difficulties, it would have been advisable for the bid to be increased to provide more 'fat' in the project economics. During the bidding process however, the owners decided to opt for a low bid price in order to ensure that a PPA was obtained.

KEY POINT

The process of deciding on the required price for electricity under a PPA requires the comparison of risk and reward.

A low price may leave the project susceptible to economic failure due to unforeseen circumstances whilst a high price may result in failure to obtain a PPA at all.

Given the comments above, a developer will require to obtain an accurate estimate of both the capital cost of the development and the likely energy production. Both of these factors will be affected by any environmental impact mitigation measures, thus highlighting the importance of clearly defining these at an early stage. Consideration of operating costs is also important and these should include suitable allowances for unforeseen breakdown.

A developer will also require to be aware of the commercial factors affecting the project including the source and cost of finance, the duration of the PPA, the likely market conditions for the sale of power after the expiry of the PPA, likely changes in inflation, taxation laws, etc. All of these factors should be entered into a comprehensive financial model in order to determine the minimum economic cost of power production.

3.2.3 Obtaining Planning Consent

Both the River Rannoch and the Elan Valley projects were developed in environmentally sensitive areas and this required that particular attention be paid to the planning consent process. Both projects demonstrated the importance of good quality environmental research and consultation with interested parties during the pre-application phase. At River Rannoch a presentation was made to all interested parties on site followed by detailed discussions with Scottish Natural Heritage, the River Purification Board and the Planning Authority. At Elan Valley a similar process was undertaken involving the Countryside Commission for Wales and the Environment Agency. In both cases all major issues were resolved prior to the formal consideration of the application by the relevant planning committee. This

undoubtedly improved the chances of obtaining approval of the formal application.

Obtaining planning consent for a project usually constitutes a major hurdle to be overcome. Hydro projects by their nature tend to be located within environmentally important areas and if not developed in a sensitive manner can cause serious environmental damage. It is therefore essential that developers recognise potential environmental problems at an early stage and plan their mitigation measures and planning application strategy accordingly.

KEY POINT

Project design to achieve mitigation of environmental impact is a complex process. Often environmental and economic factors have to be traded against one another and it is essential to have a clear understanding of both sides of the equation before undertaking the exercise.

A key feature of both the River Rannoch and Elan Valley projects was the success of the consultation process. This process was greatly assisted by appropriate research in the form of habitat surveys, hydrological modelling and visual impact assessments which were carried out prior to commencement of the consultation phase.

KEY POINT

It is essential to ensure that your advisors have properly assessed all of the potential environmental impacts and have devised adequate mitigation measures prior to commencing dialogue with statutory consultees and other interested parties.

A further feature of the River Rannoch scheme that contributed to the success of the planning application was the past record of the developer and the clear benefits which would accrue to the local area as a result of the proposals. Examples of such benefits included support to the economics of the estate (a major local employer) award of construction work to local companies and local government revenues arising through statutory rates payments.

3.2.4 Additional Consents:

The requirement for a scheme developer to obtain additional consents varies according to country, region and the nature of the site. From the research carried out it does not appear that additional consents were required for any of the study sites however the following consents may be required:

In England and Wales:

- Abstraction Licence: – Granted by the Environment Agency, providing the right to abstract water from the watercourse and usually specifying maximum flows and compensation flow levels;
- Land Drainage Consent: – Granted by the Environment Agency, providing consent to carrying out works which may affect the capacity of the watercourse to discharge flood flows;
- Impoundment Licence: - Granted by the Environment Agency, providing consent to construct a structure which impounds water on a waterway.

In Scotland:

- Discharge Consent: - Granted by the Scottish Environmental Protection Agency, providing a statutory defence to prosecution for pollution incidents (providing terms of consent are not breached);
- Section 36 Consent: - Granted by the Secretary of State for Scotland in place of planning consent for any hydro scheme with a capacity larger than 1.0MW.

KEY POINT

Consent requirements vary according to country, region and the nature of your scheme.

Make sure that you check the requirements at an early stage.

3.2.5 Landowner and Lease Issues

It was found that land ownership and lease issues were straightforward for each of the projects studied. This undoubtedly contributed to the success of the projects as this area can provide major problems which are often unforeseen at the early stage of a development.

KEY POINT

Landowner permissions and lease issues can be ‘deal breakers’.

Early identification of problems is essential to mitigate development risk.

Although problems were not encountered with the study projects, it is nonetheless worthwhile considering some of the issues which have beset, and in some cases jeopardised other proposals.

There are a number of rights which must be secured to allow the development of a project. These generally include:

- The lease of areas of ground upon which to construct the intake, powerhouse and other structures;
- Wayleaves to allow the installation, operation and maintenance of any pipelines and power lines;
- Access rights to the scheme elements as appropriate;
- (In Scotland), the right to interfere with the flow in the affected watercourses.

It should be noted that the quality of the lease documentation is fundamental to the assessment of the financial security of the project. It is essential that lease and wayleave documents are prepared by suitable advisors with this in mind. It is therefore advisable to employ advisors with prior experience of project development and financing work in the preparation of such documents.

KEY POINT

It is essential to obtain the approval of the project financiers prior to the finalisation of the lease documentation.

The quality of the lease constitutes a major element of the financiers security and they may require changes to be made before accepting the lease. Such changes are better made during the negotiation stage.

Developers should be aware of key differences between English and Scots law with respect to water rights. Whilst in England and Wales, the right to abstract water is controlled by an abstraction licence granted by the Environment Agency, no such licensing system exists in Scotland. Instead in Scotland every proprietor has the right in respect of any stream “*that, in passing through the lands of others, it shall be transmitted to him undiminished in quantity, unpolluted in quality and unaffected in force and natural direction and current*”¹. This means that in Scotland a developer of a hydro project will require to obtain the consent of the proprietor of every watercourse which is affected by the proposed development. This is irrespective of whether or not the affected proprietor will suffer any actual loss as a result of the development. The unfortunate fact is that the courts have historically upheld the rights of downstream proprietors and this means that any financier will be advised to obtain the requisite consents prior to releasing funds in respect of a development.

¹ Lord Neaves in the case of *Morris v. Bicket* (1864), 2M. 1082 (See Reference 1)

KEY POINT

There are significant differences between Scots and English law with respect to water rights.

In Scotland the consent of every proprietor of an affected watercourse is required to allow the project to proceed.

Whilst obtaining consents may seem straightforward on the face of it, complications inevitably arise due to the fact that ownership of small sections of watercourse are often unclear from old title deeds. There are projects which have suffered considerable delays and substantial legal costs due to these factors.

3.2.6 Raising Finance

It will be appreciated that the type of finance used to fund a development tends to be dependent upon the status of the developer. Of the projects studied, major utility companies using internal resources developed the Barton and Elan Valley schemes. The River Rannoch scheme was however developed by a smaller developer who utilised an element of bank debt in his funding arrangements. His success in raising bank debt was in part due to the financial standing of the estate and in part due to prior experience of the particular bank with small hydro schemes. The ability to raise funding in this way was a major factor in the success of the project as without bank funding the project could not have proceeded.

Notwithstanding the wide differences in the financial resources of developers, many of the issues remain the same. Indeed experience with other projects has demonstrated that the due diligence process employed by funders is broadly similar whether the developer be a private individual approaching his local bank or a large utility who has to apply to their board of directors for project approval.

KEY POINT

A due diligence review will almost certainly be required before funding can be obtained, regardless of the source.

The review will be detailed and will cover all aspects of the project, technical, commercial and legal.

It is essential to ensure that development work will stand up to scrutiny and that issues are resolved before the review is begun.

It is therefore recommended that developers plan the early stages of the development work so that they stand up to the scrutiny of due diligence investigation. This reinforces the need for high quality advice during the feasibility assessment stage, resolution of environmental issues, a bankable PPA and a secure lease. In addition, funders will also wish to see confirmed construction costs substantiated by firm tenders on the basis of sound contract conditions before finally committing expenditure to the project.

It is considered that the quality of the initial feasibility work, the planning consent terms and the proposed construction contracts were all critical factors in the successful financing of the River Rannoch scheme. In particular the fact that planning consent had been awarded, thus removing any hidden environmental costs, provided additional comfort to the funders.

3.2.7 Project Procurement Stage

The procurement phase normally begins once all consents have been obtained for a project and finance terms have been agreed in principle.

Experience over a number of projects has shown that this stage of the development requires particular attention if the project is to be delivered on time and within budget. As a result, financiers often require to approve proposed construction contracts as part of their due-diligence process.

Often there are delays during the planning, consents and lease negotiation phases and this can result in pressures to reduce the timescale of the procurement phase in order to allow construction to commence at the earliest opportunity. For example, one particular project that we have recently developed involved four years of negotiation in order to secure an acceptable lease. This in turn can lead to poor contract documentation, the result of which will be contractual claims and cost escalation. This appears not to have been the case with the projects studied, resulting in relatively successful construction phases.

KEY POINT

The majority of construction claims and disputes arise as a result of poor contract documentation.

The cost of a single claim can often outweigh the cost of document preparation by an order of magnitude.

Ensure that adequate time and resources are assigned to this critical area of the project in order to avoid serious problems later on.

It was noted that in each of the projects studied, standard contract terms were used, thus ensuring that an adequate level of control could be exercised on behalf of the developer by his engineer. In the case of the Barton project, the developer was able to recover some of his loss due to delays in commissioning through the liquidated damages clause. This would also have been possible on the River Rannoch scheme however the developer decided to waive his rights in this respect in order to preserve relations with the contractor.

KEY POINT

The use of standard forms of contract published by the major engineering institutions can provide significant advantages.

The contracts are tried and tested and are familiar to most contractors, thus promoting 'comfort factor' and reducing costs.

The contracts provide good protection for developers providing the supporting documentation is adequately prepared.

The contracts should be readily acceptable to financiers.

It is considered that the use of standard forms of contract made a significant contribution to the success of each of the projects studied.

3.2.8 Construction

Construction aspects tend to differ considerably between small hydro projects due to the wide range of possible designs and site conditions. This was well demonstrated by the differing conditions encountered at each of the study projects.

In each case it was apparent that the key to success lay in the combination of an experienced supervising engineer working with a competent contractor. On the River Rannoch project, the contractor was a small local operator for whom the project represented the majority of his turnover for the year. He was able to handle the project due to a close working relationship with the supervising engineer.

KEY POINT

A combination of a competent contractor and an experienced supervising engineer provides the key to a successful construction phase.

At Barton Lock, the contractor was selected partly due to his past experience with work on waterways. A combination of this experience, together with the use of an innovative design by the project engineers ensured the success of construction operations on a difficult site with very restricted access.

KEY POINT

Significant construction difficulties can be overcome through careful design of the permanent works. This often requires a combination of construction experience and innovation on the part of the project engineers.

Notwithstanding the obvious successes achieved on each project, it was noted that some adverse comment was received from the planning authorities with respect to the control of contractors. At both Elan Valley and River Rannoch, some collateral environmental damage was caused by the contractor failing to comply with the requirements of the contract with respect to mitigation of environmental impact. Whilst the impacts were minor and short-term, similar issues have nonetheless been raised by consultees on subsequent schemes. It is therefore considered essential that a developer ensures that appropriate control is exercised over contractors operations. Appropriate induction of site personnel to familiarise them with environmental requirements is considered desirable.

KEY POINT

Particular attention should be paid to requirements for environmental performance within contract documentation.

This may include performance specifications, detailed method statements and extended warranty periods in respect of reinstatement works.

A performance bond related to environmental performance may be appropriate on very sensitive sites.

Early consideration to such provisions will give comfort to planning authorities and may assist obtaining consents.

Notwithstanding the contract documents, the key to good performance is diligent site management and supervision.

3.2.9 Installation and Commissioning

The installation and commissioning phase of a project is often overlooked as it is relatively short and does not involve significant expenditure. Indeed often developers do not allocate sufficient budget to this critical phase.

It is however considered vital that this phase be given proper consideration during the planning of a project as the operational performance of the plant can be prejudiced if insufficient attention is paid to commissioning.

The commissioning phase of the River Rannoch project was particularly successful and this success is largely attributed to a combination of thorough factory testing of components before delivery to site and diligent commissioning on site.

KEY POINT

Factory testing of control and hydraulic systems can significantly reduce site commissioning times and improve overall system confidence.

Thorough commissioning provides the foundation for operational success and plant reliability, particularly where complex control systems are involved. Commissioning records provide an invaluable source of information during diagnosis of faults which may develop during operation.

3.2.10 Operation

Notwithstanding the obvious successes achieved with each of the three projects during the development and construction stages, the actual purpose of the scheme is to produce revenues. It was noted that in two cases out of the three examined, energy production had failed to meet the expected targets.

In the case of the River Rannoch project the lack of performance was almost entirely due to technical problems with the generator bearings, leading to a loss of availability of some 13% over the first 3½ years of operation. Fortunately the loss has been mitigated by insurance however the problems do underline the need for appropriate contract conditions and adequate diligence in selection of equipment.

KEY POINT

Comprehensive insurance is a must for any private developer.

Unforeseen breakdown and loss of revenue insurances are readily available and very economic when compared with the potential loss.

At Barton, the lack of performance was due to a number of factors including unexpectedly high water leakage through the adjacent canal gates, problems with trash accumulation on the screens and fatigue problems with the fabricated draft tube. These problems underline the importance of initial feasibility studies and in particular the value of operational experience in assessing energy production projections.

KEY POINT

Trash accumulation at intakes on major waterways can pose serious problems.

Developers should make allowances for downtime even if a tried and tested trash disposal system is planned for installation.

Notwithstanding the difficulties experienced by the Barton and river Rannoch projects, the Elan Valley scheme has consistently met production targets. A significant factor in the successful operation of this scheme is the use of a telemetry system which allows remote monitoring of plant from a central location. Such systems allow logging of critical plant parameters to enable diagnostic analysis and also provide alarm information to allow operatives to attend site immediately to investigate any problems.

KEY POINT

A good telemetry system can provide significant operational advantages for minimal expenditure.

Parameters can be logged and trends examined, thus enabling preventative maintenance at convenient times.

Down-time can be reduced significantly by automated call-out of maintenance personnel.

It is considered that the use of such a system at River Rannoch could have made a significant contribution to initial operational performance.

4. KEY GUIDELINES FOR FUTURE DEVELOPMENTS

Following the general comments and observations made in respect of each phase of a typical development and the specific aspects highlighted by the study projects, we can draw conclusions as to key guidelines which should be followed to ensure a successful project. These are presented in brief for each stage as follows:

4.1 Feasibility Stage

The feasibility stage is the foundation to the whole project. It is also the most risky stage as it involves payment for speculative work with absolutely no guarantee of return. It is therefore essential to manage the risk by staging expenditure and ensuring that the most critical factors are addressed first. Remember that the following will be required to allow your project to proceed to construction:

- Planning (or 'Section 36') Consent for the intake, pipeline, powerhouse and grid connection works;
- As appropriate, Discharge and/or Land Drainage Consents, Abstraction and Impoundment Licences;
- A lease and wayleaves to allow construction and maintenance of all components of the scheme;
- In Scotland, consent from all proprietors of any watercourse affected in any way;
- Funding for development and construction costs;
- (Usually) an agreement for the sale of the power to a reputable party of sound financial standing;
- A design which is capable of being built safely and within the appropriate budget;
- Contractors to carry out the work.

The feasibility stage should address the likelihood of obtaining each of the above and identify any major risk factors associated therewith. Adoption of the following guidelines should help to ensure success with this stage of the development:

- If you are not a skilled developer then do some initial background research to appraise yourself of the issues. This report should provide a good start. Other suitable material is available from the Renewable Energy Enquiries Bureau at ETSU.
- Before contacting a professional for formal assistance, carry out a layman's assessment of your site. Ask yourself if you are likely to secure landowner and planning consents for the development. Is there a good head and flow of water? Does the three phase grid supply run nearby?
- Carry out or obtain an initial desk-based appraisal of the site before committing to any significant expenditure on the project. This should

cost no more than ½ a days work and will usually be provided for free by a reputable advisor prior to charging any fee for detailed work.

- If at all possible, establish the ownership of all land required for the project and of any affected waterways prior to commissioning any detailed study work;
- Ensure that any feasibility study proposal includes for the consideration of environmental, legal and commercial issues as well as the basic technical issues.
- Limit expenditure at each stage. Ensure that all issues are progressed in parallel to avoid abortive work.
- Do not underestimate the level of diligence required to satisfy financiers and ensure that your advisors reports are suitable to support both funding and power purchase agreement applications.

4.2 Power Purchase Agreement

For most developments a power purchase agreement (“PPA”) is an essential pre-requisite to obtaining funding. To date PPAs have been obtained under the terms of the government sponsored NFFO and SRO schemes however these are to be discontinued. Future PPAs for renewable energy generators will have to be negotiated directly with an electricity supply company. Unfortunately full details of how this process will be regulated are still under discussion within the DTI at the time of writing.

Notwithstanding the above, the following guidelines should be followed in negotiating a PPA:

- Know the cost of power production. This will involve a discounted cashflow analysis of the project which should take full account of funding methods, interest rates, inflation and taxation and make adequate allowances for capital cost over-runs and lost production.
- Ensure the PPA is bankable. This means that it must be entered into with a party of sound financial standing and have the following features:
 - A clear method for determining the price of power supplied;
 - A fixed duration, preferably 20% longer than the period needed to repay the capital cost of the scheme;
 - A clear mechanism to allow the remedying events of default prior to premature termination by the purchaser;
 - Provisions to allow assignation to a third party;
- Use a solicitor with previous experience in project financing and PPA drafting\negotiation.

4.3 Planning Consents

Although obtaining planning consent for a small hydro project is by no means straightforward, we have nonetheless achieved a 100% success record over some 14 projects in ten years.

Based on this experience and the research carried out for this report, we recommend that the following key guidelines are followed in order to maximise the chances of success at this stage of the project:

- Gather sufficient information at an early stage in the project. This can be done informally through your own resources, site visits and discussions with local people but should also be backed up by professional studies into any area of concern. As a minimum we would recommend the commissioning of a 'Phase 1 Habitat Survey' by a qualified ecologist.
- Be flexible in design to accommodate environmental concerns. Remember that the most attractive design from a technical or economic viewpoint may not necessarily be acceptable from an environmental viewpoint.
- Begin consultation once you have a good understanding of issues. There is a balance to be struck between early consultation where there is a risk of being seen as ill-informed and late consultation at a stage when plans cannot easily be changed. We therefore recommend starting consultation once the initial habitat surveys have been completed and an outline design, which takes account of environmental concerns, has been produced. We recommend beginning consultation with all parties simultaneously, probably by way of a presentation and meeting on site, in order to avoid being seen to favour one party over another.
- Be prepared to listen and make concessions. Whilst this point is addressed in part above, it is nonetheless considered important to address directly the concerns of each interested party or consultee. It is better to make a concession in response to a specific request, thus reinforcing 'ownership' and enhancing goodwill.
- Do not submit formal application until informal approval is obtained. Experience has shown that the process of consultation and subsequent modification of design proposals is better carried out outwith the constraints of the formal planning application process. This avoids the need for a succession of formal amendments to the application (involving multiple copies of documents and inevitable delays). It has also been found that well-considered applications where issues have been resolved in advance are treated more favourably by the planning authorities.
- Allow 12 months for the process. Whilst this might seem a long time for a planning application, we consider this to be the minimum time required for a competent consultation and subsequent application.

4.4 Other Consents

As noted in Chapter 3, the additional consents necessary to allow your project to proceed vary according to country, region and nature of the development. From experience we would recommend the following key guidelines for success with this stage of the project:

- If in England or Wales, contact the Environment Agency at an early stage to establish what additional consents will be required. The minimum will be an Abstraction Licence.
- If in Scotland contact the Scottish Environmental Protection Agency (SEPA) to determine if a Discharge Consent will be required for the project.
- As with the planning application, consult early, listen to concerns and make suitable accommodation within the designs.
- If Land Drainage Consent or an Impoundment Licence is required then you may be expected to produce a significant level of technical detail for approval by the EA. Establish at an early stage what this will involve and make the appropriate allowances within the budget and timescale for your project.

4.5 Landowner Consents and Leases

Obtaining consent to your proposals from the owners of the affected land can often be more difficult than obtaining planning consent. Commonly landowners view their property within a very different set of values to a power station developer and this should be appreciated at the outset. Landowners can be expected to be defensive at first and often need careful handling in order to secure terms which will allow the project to proceed.

The following guidelines should be of assistance:

- Begin initial negotiations as soon as possible but not before you have your facts straight! Clarity in your initial communication is essential to maintain dialogue.
- Expect initial resistance until benefits are appreciated. Ensure that you empathise with the landowner's position and sensitivities but know your proposals well and provide ready answers to any concerns. In particular be clear as to the benefits that the project will bring and do not make the mistake of glossing over any environmental risks.
- Do not risk landowners hearing of proposals from others – this can prejudice future negotiations. Nothing is more certain to jeopardise a good project than a landowner discovering through hearsay that his site is being considered for development.
- Use experienced advisors in the preparation of lease documents. A hydro project lease need not be complex but it must be competent. In particular in Scotland it must include for securing the necessary water rights. The lease must also be bankable. The use of a solicitor with

prior experience in this field can help to avoid delays and un-necessary legal costs.

- Do not finalise leases until financiers are happy. The lease is one of the prime assets upon which project finance is secured. Given the inevitable difficulties in negotiating leases, it is better to ensure all alterations are incorporated before the final document is signed. Financiers will have certain requirements of the lease document and hence prior approval is essential before the deal is concluded.

4.6 Project Finance

Funding of the project from inception to completion requires careful consideration. The most appropriate funding mechanism will vary according to the particular situation of each developer and it is strongly recommended that proper advice be sought from suitably qualified and experienced advisors.

In general terms the following guidelines should assist with securing a successful outcome to this stage in the project:

- Understand risks and rewards of funding development stage. As noted at the beginning of this chapter, the development stage is speculative with no guarantee of returns. It is however at this stage in the project that the inherent value is created and this value can be substantial for a good project, whether realised in terms of future cashflows or as a lump sum paid by a utility company for the development rights.
- Shop around and consider a build-operate-transfer or 'BOT' deal with a major utility. In a BOT deal, the utility will usually purchase the development rights (PPA, planning consent and leases) from the developer for a sum equal to the net present value ("NPV") of the future cashflow stream. The utility will then assume the risk of building and operating the plant and will normally return the plant to the developer or the landowner after a period of around 25 years. Whilst such a deal appears to cut the developer out of the main part of the action, the economic returns to the developer are often maximised. It is worth noting that the cost of small scale project finance is far greater than the cost of a BOT deal.
- Do not under-estimate the due diligence requirements of any funding source. A competent party offering to finance a project will wish to ensure that his lending or investment is safe. Accordingly they will always carry out a detailed due diligence review. Such a review will usually be carried out by third party engineers, lawyers and accountants who will have a responsibility to report any risk factors to their client. The level of diligence will ultimately be determined by the risk appetite of the funder. Accordingly, all work should be planned in such a way as to meet the requirements of a due diligence review.

4.7 Procurement

The procurement phase is critical in any project to ensure that contractual problems do not arise subsequently. As noted in Chapter 3 there is often pressure to reduce the time taken for this phase in order to bring forward the time when the project begins to produce revenues. It should be remembered that the majority of construction claims arise as a result of poor contract documentation and that a single claim can easily amount to the value of several months generation revenues.

This stage should therefore be treated as critical. The following guidelines are recommended:

- Ensure sufficient time for the tendering process. It is essential to allow sufficient time for your advisors to prepare tender documents and to allow contractors adequate time to submit tenders. A minimum of 12 weeks is recommended.
- Employ experienced professionals to prepare tender documents and manage the tender process. Check that they have prior experience of similar works and seek references from previous employers.
- Be clear as to the level of risk that you will accept and instruct your advisors accordingly. Remember that there is a balance between construction risk and price.
- Use standard forms of contract. Standard forms of contract have been devised by the various engineering institutions. These are well known by contractors and if the worst happens, are supported by a wealth of case law. Ensure the standard form used is appropriate to the works and the level of risk that you have decided to accept
- Ensure that the specification is clear and concise. Use a standard general specification (e.g. a water authority general specification) and add suitable particular specifications.
- Ensure that both contract conditions and the specification reflect the environmental requirements as set out in the planning consent and any leases for the site. Consider appropriate measures for control of the contractor to ensure environmental standards are met.
- Take advantage of economic rates offered by local contractors but ensure that you allow for the provision of an appropriate level of supervision according to the particular contractor's capabilities.
- Provide the contractor with as much information as possible about the site, the consents, the environmental constraints and the project in general. Make sure that information is factually accurate and finally ensure that the contractor is responsible for the checking of the accuracy of any information provided.
- Allow due time for the assessment of tenders and subsequent discussions with the favoured contractor. Ensure any meetings are minuted.

4.8 Construction

Providing your advisors have carried out the feasibility and procurement phases effectively, the construction phase should be relatively straightforward, at least in theory. Difficulties will inevitably arise if the unexpected happens and success of this part of the project will be dependant upon the developer's ability to manage any unexpected events. Such events can range from ground conditions to adverse weather and may include commercial risks such as financial failure of a contractor.

Management of the construction process should only be undertaken by experienced professionals and it would not be appropriate to list the full scope of their services herein. The following key points should however prove of assistance:

- The key to a successful construction phase lies in detailed planning, programming and control. This should involve traditional techniques such as the preparation of a work breakdown structure and fully resourced project programme. Who actually carries out the planning exercise will depend upon the form of contract used, however close monitoring of the plan by the developer or his advisors is essential.
- Check the credentials of the proposed site manager or 'Agent' and reserve the right to have him changed if performance is not satisfactory. The quality of site supervision an essential ingredient to successful construction. Unfortunately, a contractor is often only as good as his man on site.
- Insist that contractors provide a detailed safety and environmental induction of all staff when they start work on site. The success of a project construction phase is often judged by such factors as collateral environmental impact caused or the safety recorded on site.
- Communication is vital in order to retain project control, particularly in the event of unexpected circumstances. Regular meetings on site attended by all relevant parties are recommended.
- Maintain a good working relationship with the landowner, the environmental consultees and the planning authority through regular meetings and updates.
- Devise a strategy for the rapid mitigation and/or resolution of problems. This should include such measures as 'early warning meetings' and brainstorming sessions. In the event of a problem which may give rise to contractual disputes, ensure that detailed contemporaneous records are kept as these will be essential to future resolution.
- Ensure that you do not accept the completed works until you are satisfied that all outstanding matters have been adequately attended to.

4.9 Installation & Commissioning

Careful installation of the plant and equipment and thorough commissioning to ensure that all systems are set up and operate as designed is essential if problems are to be avoided during the operation phase. Often there is pressure on installation and commissioning personnel to achieve power production at the earliest date. It is also often assumed that the timescale and budget required will be small in terms of the overall project. Whilst there are ways of minimising both time and cost, this should not be done at the expense of system integrity.

The following guidelines should help to ensure that the installation and commissioning phase is effective:

- Recognise that this is an important phase. Careful installation and diligent commissioning are essential to ensure trouble free operation.
- Allow sufficient time and budget in your planning. Requirements will vary according to the nature of the project but be conservative.
- Ensure that installation and commissioning is supervised by a skilled engineer with prior experience of commissioning hydro plant.
- Insist on factory testing of control and hydraulic systems if possible. This will allow any problems to be resolved before equipment is delivered to site and will assist in keeping commissioning time to a minimum.
- Ensure that all systems are tested under as many conditions as possible. Ask random ‘what if’ questions and expect to see adequate demonstrations of satisfactory plant performance in response.
- Ensure that good records kept by the commissioning engineer and do not accept the plant for taking over until you have a copy of all of these. Commissioning records can form a valuable data set for evaluation of performance (and non-performance) in the event of future problems.

4.10 Operation

When all is said and done, the aim of any hydro project is to generate a return on investment. Often projects are cited as being successful just because they achieved commissioning, whilst their operational performance may be very poor. Whilst satisfactory performance is a function of many aspects of the project from the initial design, through implementation to uncontrolled elements such as rainfall, there is no doubt that efficient operation can provide significant benefits.

Key guidelines for the operational phase of a project are as follows:

- Implement a planned maintenance system. Planned maintenance is essential for trouble free operation. A well implemented system need not interfere with normal plant operation. Regular thorough inspections can often indicate the need for preventative maintenance which is significantly cheaper than the cost of dealing with unforeseen breakdown.

- Use a remote monitoring system. An automated alarm system is essential for any commercial plant. Systems are relatively inexpensive and the benefits are significant. A typical 1.0MW plant will earn £1,000 per day in revenues. The automation system need only avoid 20 hours downtime in a year to be financially justified. In reality, the reduction in downtime is likely to be many times that value.
- Monitor logged data. Examination of logged data records provide an invaluable indication of plant performance and can highlight areas that require attention long before they might have become apparent through daily manual inspection of the plant.
- Allow for down-time in first year of operation. Notwithstanding diligent commissioning, it is nonetheless not uncommon for equipment to experience some teething problems. Such problems are normally minor in nature, emanating from such areas as the control software. They can however cause some loss of production during the first months of operation. It is important to ensure that the commissioning engineer is available at short notice during the ‘running in’ period to resolve any problems that do emerge. It is also important to factor such losses into the project economics. We would recommend a 10% reduction in revenues in the first year as adequate.
- Allow for lost production due to trash on major rivers. Experience demonstrates that trash accumulation on intake screens on major rivers is a serious problem, particularly during the autumn/winter months. Whilst most developers include automated trash screen cleaners in their schemes, such devices have varying degrees of effectiveness and rarely provide full protection from any loss. Use of proprietary screen cleaners rather than bespoke units will improve performance however some loss may still be experienced due to trash accumulation within the turbine. We would recommend a loss allowance of up to 15% of normal output during the period from mid October to the end of December.
- ‘Drive’ the plant. Take an active interest in performance, ensure that maintenance is carried out and pay particular attention to down-time which should be minimised. Experience shows that plants which are actively ‘driven’ achieve superior performance.

4.11 Concluding Remarks

It will be appreciated from the above that the development of a small hydro project involves many phases within which there seem to be an endless list of pitfalls. We would however encourage potential developers not to be discouraged as notwithstanding the many difficulties faced, success is undoubtedly possible.

We would consider the over-riding key to such success is to seek early advice from a hydro professional with a track record of successful developments.

We would recommend engaging such a professional to manage the development process for you whilst you use the guidelines outlined in this chapter as a cross-check as to the advice that you are given.

Good Luck!

5. REFERENCES

1. The Law of Water in Scotland by Ferguson. W Green & Sons, Edinburgh, 1907.

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HYDRO PROJECTS**

APPENDIX A

CASE STUDY

RIVER RANNOCH HYDRO PROJECT – ARTORNISH ESTATE

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1. General

1.1 Introduction

This case study provides details of a 715kW grid connected hydro-electric plant constructed by the Ardtornish Estate Company on the River Rannoch in Morvern, Argyll.

The plant was commissioned in April of 1996 and has been selected for study as it provides a particularly good example of good practice during the development, consents and constructions stages of the project.

1.2 Data Collection

Data was collected from the developer, the planning authority, Scottish Natural Heritage and the Scottish Environment Protection Agency by means of questionnaires which were designed to obtain specific information with respect to the project.

Further information was obtained from the archives of Caledonian Energy Management Limited which contained all of the original project development files and data.

1.3 Acknowledgements

Particular acknowledgement is due to the Ardtornish Estate Company for their assistance in providing information and data and their permission for it's use.

Further acknowledgement is due to Highland Council Planning Services, the Scottish Environmental Protection Agency and Scottish Natural Heritage for their assistance.

2. Project Background

2.1 Inception

The opportunity for hydro generation at the site was identified by the owners of the Ardnornish Estate in the early 1980's. The River Rannoch has an average daily flow of 1.5 m³/sec fed by a catchment of some 27km² in an area with an average rainfall of 2170mm. The lower section of the river falls some 65m within a distance of 800m and this fall together with the available flow provided the opportunity for the development of a hydroelectric power station.

2.2 Project Aims

The primary aim of the project was to create a long-term revenue earning asset in order to help secure the long term viability of the Ardtornish Estate as a business unit.

The development of a hydro-electric station was seen as an ideal means of creating such an asset. Firstly the revenue stream was seen as relatively secure, being supported initially by the Scottish Renewables Order and latterly

by a perception that both demand and price for electrical energy would rise in the future. Secondly, the scheme was considered to provide environmental benefits in reducing national dependence on fossil fuels whilst having minimal negative environmental impact at a local level.

Notwithstanding the above, it was necessary for the project to be justified in economic terms and hence it had to provide a return on investment which was competitive with alternative uses of capital.

2.3 Technical Description

The station uses a Francis turbine with a rated discharge of 1.4m³/sec on a rated head of 57m to drive a 415Volt synchronous generator to produce an electrical output of 715kW. Power is exported to the local grid network at 11,000 Volt via a step-up transformer.

Water is supplied to the turbine by 725m of 800mm diameter GRP pipeline laid both above and below ground. An inclined screen 'side' intake constructed in reinforced concrete diverts water from the River Rannoch to the pipeline. The turbine house is a block work building on a reinforced concrete raft foundation and was designed to match the architecture of other buildings on the Estate.

The station is expected to produce an annual output (long term average) of 2850 MWh.

3. Project Development

3.1 Feasibility/Resource Assessment

Following the identification of the potential resource, the Estate commissioned a detailed feasibility study for the project. This study was carried out by Messrs Mander Rakes and Marshall in 1987 and concluded that the site had potential for generation of approximately 600kW using a Turgo-impulse type turbine.

A subsequent review of the project was carried out by Edinburgh Hydro Systems Ltd ("EHS") in 1992 which confirmed the results of the MRM study and provided an updated economic appraisal of the project. EHS also recommended a slight increase in the design rating for the project and their revised design formed the basis of the final design as built.

3.2 Power Purchase Agreement

A power purchase agreement ("PPA") was obtained for the project under the first Scottish Renewables Obligation in December 1994.

The application was made on behalf of the Estate by EHS and was supported by copies of the feasibility study and planning consent for the project. The application did not experience any difficulties during the technical or economic scrutiny by OFFER and was greatly assisted by the existence of the detailed study and planning consent.

3.3 Planning Consents

An application for planning consent was made to Highland Regional Council in August 1993 and consent was awarded in October of that year. The planning consultation and application process was undertaken by EHS who worked very closely with the Estate throughout the process. It is notable that the Estate felt confident enough about the economics of the project and the likely outcome of the SRO bidding process to commit to the necessary expenditure prior to the award of the PPA. This was made possible in part by the detailed technical and economic assessment of the project contained within the feasibility study and partly by the confidence provided by statements made by the Scottish Office in relation to their intentions in connection with SRO1. Key factor in success of the project.

The planning application process contained a number of key phases:

- Initial assessment of the site to determine areas of environmental sensitivity or likely concern;
- Informal consultation with the statutory consultees at a local level;
- A public meeting and presentation at which the project plans, impacts and benefits were explained to representatives from the planning authority, statutory consultees, community council, local businesses and wider local community;
- Modification of the project plans to take account of issues raised during consultation;
- Informal approval from consultees;
- Formal planning application and subsequent approval.

There were no significant issues raised either as a result of the consultation process or, indeed subsequently during construction or operation. The issues which were however raised were as follows:

- Protection of the aquatic environment of the River Rannoch, requiring measures for prevention of pollution during construction and compensation flows during operation.
- Visual impact of the completed works, requiring attention to the architecture of building and the colour and routing of the overground pipeline.
- Protection of existing natural woodland in the vicinity of the turbine house, requiring restrictions on tree felling and care with selection of grid connection route;
- Public safety during construction, requiring signage and information;

In addition to the planning consent, it was also necessary to obtain a Discharge Consent from the Highland River Purification Board. Application for this consent was conducted in parallel with the planning consent and the HRPB were consulted in respect of both consents.

3.4 Detailed Design/Procurement phase

Preparation of the detailed design and specification was carried out by EHS who were appointed as consulting engineers for the project. Tenders for construction of the works were sought from suitable contractors under two packages of work. The first package was for the supply of the turbine, generator, controls, switchgear and ancillary equipment. The second package was for the construction of the civil engineering works. In addition minor contracts were let for the supply of the pipeline materials and the installation and commissioning of the plant and equipment.

Contracts were let under standard conditions of contract with minor amendments and administered by EHS as Engineer to each contract.

3.5 Construction Phase

3.5.1 Civil Engineering Works

Construction of the civil engineering works was carried out by a local civil engineering contractor and commenced in May 1995. Minor difficulties were experienced due to the contractor's lack of care with respect to the local environment. On occasion heavy plant was allowed outwith the permitted working areas, there was collateral damage to trees during excavations and some disturbance of the stream bed resulting in silt pollution downstream. These factors required a level of supervision by EHS which was greater than originally anticipated.

Final completion of the civil engineering works was some two months later than programmed due primarily to under-resourcing of the work by the contractor. Notwithstanding the delays, the final quality of the completed works was acceptable and there were no claims related contractual problems.

3.5.2 Electrical and Mechanical Equipment

Supply of the electrical and mechanical plant and equipment was carried out by a major UK turbine supplier and the contract was placed in April 1995. Equipment was delivered to site in February 1996 and commissioned over a period of six weeks. Initial synchronisation was achieved on 1 April 1996 and commercial operation commenced approximately 1 week later.

3.5.3 Grid Connection

The grid connection to the project was provided by Scottish Hydro-Electric plc (now Scottish and Southern Energy plc) ("SSE") and involved the up-grading of the local supply network including the installation of some 2.2km of new 3 phase 11kV overhead line through a Site of Special Scientific Interest ("SSSI").

All of the consent, design and planning issues were handled by SSE and the connection was provided for a reasonable cost and on programme.

3.6 Operation Phase

Operation of the station has been carried out by Estate personnel with maintenance support being provided by the equipment supplier.

Although the daily routine of operation has been straight forward, assisted by a control system which works well, there have been various problems which have affected the performance of the plant. These are as follows:

- Initial problems with generator bearings led to down-time in first season.
- This was exacerbated by particularly dry summer in 1996 and 1997.
- Additional problems with generator circuit breaker;
- Recent problems with generator bearings again.
- Output in 1998 was satisfactory which indicates that long term average can be achieved as projected providing generator bearing problems are finally resolved.

The result of these problems is that the total plant availability since commissioning has been only 87%. This has had a significant effect on the financial returns from the project.

4. Conclusions

4.1 General Conclusions:

Following the research into the project and consideration of the information obtained, the following conclusions can be drawn:

1. The project was very successful in initial stages in obtaining consents and the power purchase agreement. This initial success was largely due to the following factors:
 - Accurate feasibility study providing confidence to proceed;
 - A flexible and integrated approach to the design of the works whereby the legitimate environmental and community concerns were addressed and appropriate changes made;
 - Detailed consultation with the planning authorities and the use of local contacts through the estate for liaison;
 - Highlighting the local benefits of the scheme;
 - Clear policy statements from the Scottish Office which again assisted with confidence building and allowed the Estate to invest in appropriate level of service in making the SRO application.
2. The construction stage of the project was a success despite minor cost over-runs and delays in commissioning. Delays did not impact on economics due to terms of SRO. Specific factors which contributed to this success were as follows:

- The use of an experienced professional firm to supervise the works;
 - The use of standard forms of contract and specification which provided a framework for the control of contractors;
 - The use of a locally based civil engineering contractor;
3. The operational stage of the project has not been successful to date due primarily to technical problems with the generating equipment. In particular problems associated with the design of the generator bearings have prejudiced the project economics.
 4. Notwithstanding, long term objectives may still be met if initial technical problems with the generator can be overcome.

4.2 Specific Examples of Good Practice:

From the above, it is possible to cite specific examples of good practice which contributed to the success of the scheme and which are recommended for adoption in future developments. These are as follows:

- Professional resource assessment, staged to ensure expenditure/risk profile is managed;
- Consultation in planning application and integration with ongoing design process;
- Standard forms of contract & professional supervision;
- Use of local contractors in conjunction with experienced supervision;
- Factory testing of the control systems and hydraulics;
- Diligent commissioning of the plant.

The above examples are discussed in greater detail within Section 1 of this report.

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APPENDIX B

CASE STUDY

ELAN VALLEY HYDRO PROJECT – HYDER INDUSTRIAL LTD

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1. General

1.1 Introduction

This case study provides details of a 4.2 MW grid connected hydro-electric scheme constructed by Hyder Industrial Ltd in the Elan Valley in Mid-Wales..

The scheme was commissioned in the spring of 1997 and has been selected for study as it provides a particularly good example of a multi stage cascaded scheme executed within a particularly environmentally sensitive area.

1.2 Data Collection

Data was collected from various sources by means of questionnaires which were designed to obtain specific information with respect to the project and by follow-up discussions.

Further information was obtained from Hyder Consulting Ltd who were involved in the original development work and thus had access to further data on the project.

1.3 Acknowledgements

Particular acknowledgement is due to Hyder Industrial Limited and Hyder consulting Limited for their assistance in providing information and data and their permission for it's use.

Further acknowledgement is due to Powys County Council and the Environment Agency for their assistance.

2. Project Background

2.1 Inception

Investigations into the new potential for hydro power generation was first undertaken in 1990 as part of a review of Hyder's operational water supply and land asset base. The development of the Elan Valley scheme was progressed as a part of an expanding portfolio of renewable generation projects. The nature of small hydro was particularly compatible with core group experience and understanding of water supply and control and the availability of existing major infrastructure

2.2 Project Aims

The project was developed by Hyder Industrial Limited as a commercial venture outside of the main regulated water business. The project objective was to provide a sustainable long term revenue stream from renewable energy. Success in demonstrating this objective could be achieved would provide essential reassurance to allow continuing expansion of the strategy to develop a renewable energy business. The project was required to demonstrate that the project risks, predicted outputs and levels of investment could all be managed to deliver the commercial returns required. The principal deliverables against

which performance was measured were firstly the completed construction cost and then the net returns from the annual energy sales once all operational costs had been accounted for.

2.3 Technical Description

The project is located in mid Wales and involved provision of 5 separate turbines in new structures to utilise the spill and regulation flows from a series of water supply reservoirs and dams built between 1900 and 1950, primarily for water supply to Birmingham. The reservoirs are operated for water supply by Severn Trent Water.

The project involved construction of five generation stations to utilise the head from existing storage dams and water supply infrastructure. The following principal details of the installed equipment indicate the variety of installation necessary to accommodate the head and flow availability at each of the sites.

Site	Craig Goch	Pen-y Garreg	Caban Coch	Foel Tower	Claerwen
Maximum head	36.5m	37.5m	37m	13.5m	56m
Peak Power	480kW	810 kW	950 kW	300 kW	1,680 kW
Turbine type	Francis	Francis	Francis	Kaplan	Francis

The five individual sites are spread over a considerable area and are interconnected by 12km of 11kV cabling works. A further 7km of 11 kV, buried transmission lines were required to provide connection to the grid from a single point of supply. The combined total gives a maximum nominal output of 4.2MW at the point of connection to the grid.

3. Project Development

3.1 Feasibility/Resource Assessment

Initial concept feasibility works were commissioned in 1990 - 1992 by Hyder Industrial Limited. Hyder Consulting's Environmental Division were employed to determine the hydrometric parameters, flow availability and catchment run off characteristics.

During 1993 and 1994, the outline engineering design concept and principal planning submissions were developed for Hyder Industrial by Mott MacDonald to allow cost estimates and technical feasibility to be confirmed for the purposes of submissions under the NFFO bid. The water resource studies were undertaken and audited using Hyder Consulting's hydrological team. Hyder Consulting also undertook the project cost modelling and risk assessment studies on behalf of Hyder Industrial.

The water resource assessment was undertaken using conventional Institute of Hydrology methods to model the catchment in conjunction with historic gauged and metered data. The operation of the project has demonstrated close correlation with the predicted outputs and flows both annually and seasonally.

3.2 Power Purchase Agreement

A power purchase agreement (“PPA”) was obtained for the project under the third Non Fossil Fuel Obligation round in 1995.

The application for a PPA was made by Hyder Industrial Limited under the procedures set down for NFFO3. The process highlighted the importance of early environmental discussions and technical assessment to confirm realistic programmes of work and achievable project development, capital and operational costs.

The NFFO applications procedure did not cause undue difficulties as considerable efforts had been put into the project on a speculative basis during the feasibility studies. This included environmental appraisal and scoping studies undertaken prior to the NFFO submissions to ensure principal issues, risks, constraints and probable mitigation measures for the project had been identified in advance of the submission.

3.3 Planning Consents

The scheme lies within an area with high visual amenity value and 90% of the estate is designated as Sites of Special scientific interest. The Elan valley is also a major tourist destination and attracts 300,000 visitors a year. These factors led to development of solutions that utilised below ground structures and modifications to existing chambers to minimise visual impact.

Environmental assessments were required as the sites are all within an area of outstanding natural beauty. The project also required careful consideration of the impact of the network of power transmission cables that linked the five sites to the common grid connection point. Cabling was buried to minimise intrusion.

In developing the projects, environmental statements were produced to address concerns of the potential impact during construction and operation on flora and fauna and from visual and noise impact. Close liaison with the Environment Agency and Countryside Commission for Wales was maintained throughout the project to develop mutually acceptable solutions in parallel with the technical development. Of particular concern were the provisions necessary to control access and materials delivery during the construction period.

The planning applications were prepared by Mott MacDonald with support from Hyder Consulting on specific issues and submitted by Hyder Industrial. The principal planning and project consents were received by the spring of 1995. The resolution and determination of the consents was one of the long lead in and critical path items that dictated the progress of the overall project.

3.4 Detailed Design/Procurement phase

Detailed engineering design was undertaken in 1995 by Hyder Consulting Limited under the terms of the standard ACE conditions for design as lead consultant. Hyder Consulting provided full project management, engineering design (civil and MEICA works), contract management, CDM planning supervisor and construction and commissioning attendance services for the project.

The procurement of works at all five sites was undertaken using the following principal contracts -

- 1) Civil engineering works - Procured using the ICE Conditions of Contract with staged completion targets and a standard measured works basis
- 2) MEICA equipment and plant - procured using modified G90 conditions of contract
- 3) Cable and grid connection - a direct negotiated contract with the Regional Electricity Company (REC)
- 4) Cabling between the sites and the point of grid connection

The contract works under 1 and 2 comprised works for all five sites

With the exception of the grid connection contract where a single REC provided a quotation, the projects were let on a turnkey basis with open and competitive tendering being used to determine the appropriate supplier. Under this process price was considered in conjunction with the quality of references and experience of similar works. This was particularly important for the selection of the civil engineering works contractor due to the proximity to existing dams, difficult access for works and the public and environmentally sensitive nature of the sites.

Significant modification to the civil engineering design were found to be necessary following selection of the chosen turbine supplier due to the specific details and need to optimise the value of all works. The modifications were required to facilitate use of standard and common turbine components where possible to ensure the project remained within the parameters and constraints dictated by the NFFO bid price.

3.5 Construction Phase

The civil engineering works were tendered in late 1995 and after evaluation of tenders awarded to Taylor Woodrow. The MEICA contract works were undertaken by Biwater Hydropower, interconnecting cabling works by Balfour Kirkpatrick and the Grid connection works by SWALEC.

The construction programme for the civil engineering works achieved substantial completion within 12 months of award. The turbine supply and commissioning took approximately 15 months to complete. The interface and exchange of information with the turbine supply contract was critical to works progress. Of particular note were the methods used to gain access to restricted and difficult terrain. At Claerwen use of a tower crane and significant

temporary works to stabilise sidelong ground were required to enable construction.

Even with staged completion provisions, the final commissioning and completion of all works under the contracts was complicated by the need to maintain the civil engineering contractors presence on site longer than would otherwise have been necessary simply to co-ordinate final and minor building works under the civil engineering contract that could only be completed after installation of the principal MEICA plant. In turn this work had to be completed before final commissioning could be undertaken.

Commissioning tests commenced in late 1996 and were fully completed by the spring of 1997.

3.6 Operation Phase

The level of maintenance and site attendance required has been very low following the initial bedding in of plant and control systems and familiarisation with operational procedures.

The plant is operated and monitored remotely by Hyder Industrial Operations staff using telemetry links. Attendance at site is minimal and limited to planned maintenance required for routine greasing and checks of oil and fluid levels or call outs to respond to system alarms. The telemetry and monitoring system incorporates automatic alarms and methods to shut down the plant should a fault occur. Down time for maintenance has been minimised by planning maintenance for times of low reservoir levels and flows.

The output from the plant has consistently achieved the predicted annual energy forecasts.

4. Conclusions

4.1 General Conclusions:

The project performance has been closely monitored and has produced the predicted levels of output. The development, construction and operational costs were of the same order as the predictions ensuring required project returns have been achieved.

The NFFO bid process gave little opportunity for accommodating the risks of unforeseen circumstances or developments resulting from issues arising after submission of the NFFO bid. This required considerable effort and innovative design solutions to ensure the commercial objectives could be maintained without compromising engineering, environmental and planning constraints.

The project successfully dealt with sensitive environmental issues largely through early and maintained discussion with the principal parties for the duration of the development and works periods. This process allowed development of an understanding of diverse viewpoints and issues to allow agreed and achievable solutions to be formulated that satisfied the diversity of issues raised. This dialogue was a key aspect that contributed to the success of the project and ensured key issues were addressed in working method statements and specifications. The trust built up in developing the project facilitated rapid decision making during the construction period when, for example, opportunities for alternative methods of access became apparent as the works progressed.

Since completion the project has received environmental awards in recognition of the successful implementation of the development and attention to environmental details.

4.2 Specific Examples of Good Practice:

From the above, it is possible to cite specific examples of good practice which contributed to the success of the scheme and which are recommended for adoption in future developments. These are as follows:

- Use of experienced professional advisors
- Detailed liaison with statutory consultees during planning application
- Use of buried powerhouses
- Multi-procurement for several projects at once

The above examples are discussed in greater detail within Section 1 of this report.

CONTRACT No. H/01/00049/00/00
MONITORING OF SUCCESSFUL RENEWABLES OBLIGATION SMALL
HYDRO PROJECTS

APPENDIX C

CASE STUDY

BARTON LOCK HYDRO PROJECT

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1. General

1.1 Introduction

This case study provides details of a 660W grid connected hydro-electric plant constructed by a subsidiary of NORWEB plc on the Manchester Ship Canal some 8km from the centre of the City of Manchester.

The plant was commissioned in November of 1994 and has been selected for study as it provides a good example of the development of a low-head hydro project within the existing infrastructure of a navigable waterway. The project presented both technical and commercial challenges and the experience gained therefrom provides valuable lessons for future developments of a similar nature.

1.2 Data Collection

Data was collected from various sources by means of questionnaires which were designed to obtain specific information with respect to the project.

1.3 Acknowledgements

Particular acknowledgement is due to Wilson Energy Associates Ltd for their assistance in providing information and data and their permission for its use.

Further acknowledgement is due to Trafford Council for their assistance.

2. Project Background

2.1 Inception

Barton Lock is one of five sets of locks on the Manchester Ship Canal. This 58km long waterway provides access to the City of Manchester for ocean going ships.

At Barton the difference in water level between the upper and lower reaches is normally 4.57m. The canal is fed by the river Irwell above Barton and at Barton the long term average daily flow is $18.0\text{m}^3/\text{sec}$.

The combination of the head and flow, together with the existence of civil engineering structures provided a significant opportunity for hydropower development at a number of locks on the Manchester Ship Canal. This opportunity was recognised by Dr. Eric Wilson in the early 1980's.

The initial promotion of the scheme was conducted by Dr. Wilson in association with Hydro Energy Developments Ltd of Cannonbie, Dumfriesshire. A power purchase agreement were secured by HEDB who subsequently transferred the development rights to NORWEB plc prior to construction of the project.

2.2 Project Aims

Owing to changes in the ownership of the station it has not been possible to obtain first hand confirmation of the project aims and objectives.

It is reasonable however to assume given the nature of the developer that the primary aim was to generate a financial return from the specific project within the wider context of the development of a renewable energy generation business.

It is known that the developer has subsequently withdrawn from the renewable energy generation business and hence it is not possible to establish if the project met the original aims.

2.3 Technical Description

The station uses a horizontal semi-Kaplan turbine with a rated discharge of 18.5m³/sec on a rated head of 4.4m to drive a 415Volt induction generator through a speed-increasing gearbox to produce an electrical output of 660kW. Power is exported to the local grid network at 11,000 Volt via a step-up transformer.

The turbine and associated equipment have been installed within a disused pumphouse located between a disused canal lock and a set of control sluices. Water is supplied to the turbine through a culvert constructed within the lock wall leading to a 3.0m penstock. The culvert is fed by an inclined screen 'side' intake constructed in the wall of the upper canal basin. The screen is equipped with an automated trashrake and isolation of flows in the penstock is achieved by means of a sluice gate located upstream of the turbine. Water is discharged from the turbine to the lower basin via a fabricated steel draft tube which is suspended from the powerhouse structure.

The limited access to site and the difficulties presented by the need to construct the project within existing (and partially un-known) civil works structures presented a significant challenge to the design and construction team.

The design of the station anticipated an annual average energy production of 3200MWh.

3. Project Development

3.1 Feasibility/Resource Assessment

A detailed feasibility study in connection with the nearby Irlam Lock site was conducted by Dr. Wilson. This study established the flow regime for the canal and provided much of the basic data upon which the plans for the Barton scheme were founded. Subsequently a secondary study was conducted into the Barton scheme which focussed on the condition of the existing civil engineering works.

3.2 Power Purchase Agreement

A power purchase agreement was obtained for the project under the first Non-Fossil Fuel Obligation in 1991.

The application is understood to have been made by Hydro Energy Developments Ltd on the basis of the study work carried out by Dr Wilson. Further details of the application are not available.

3.3 Planning Consents

An application for planning consent was made to Trafford Council in 1993 and consent was awarded in 1994. The planning consultation and application process was undertaken by Dr Wilson and has been confirmed by Trafford Council as being very straightforward. This was due to the fact that the proposed scheme made only minor alterations to the existing civil engineering infrastructure and that there were not perceived to be any adverse environmental effects arising from the proposals.

3.4 Detailed Design/Procurement phase

The project was designed and constructed by Renewable Energy Associates Ltd of Bramhall, Stockport on a turnkey basis. It is understood that the design and construct contract was let under IEE MF/1.

Major sub-contracts were let for the construction of the civil engineering works and for the supply of the turbine and draft tube. Further sub-contracts were let for the supply of the generator, gearbox, hydraulics, penstock gate, screen cleaner and control/electrical system. This multi-procurement strategy achieved significant cost savings when compared to a traditional “package” from a single plant supplier.

3.5 Construction Phase

3.5.1 Civil Engineering Works

Construction of the civil engineering works was carried out by Dew Group Ltd under sub-contract to REAL. The construction sequence required careful planning and execution due to the restricted access and working area. Difficulties were encountered during excavations for construction of the culvert due to unforeseen obstructions in the form of extremely hard concrete. A significant success was the adaptation of the permanent works trash screen for use as a clam shell coffer-dam to allow de-watering of the works whilst constructing the new water offtake within the existing lock wall.

Construction commenced in April 1994 and was completed in November of that year.

3.5.2 Electrical and Mechanical Equipment

The turbine and draft tube were manufactured by Newmills Hydro of Ballycarry, Northern Ireland. The generator was supplied by Alconza, Spain, the gearbox by David Brown Radicon Ltd, Huddersfield and the control and

electrical system was supplied by Power Systems Ltd, Bristol. Overall system engineering was carried out by REAL.

Installation and commissioning was carried out by Newmills Hydro and Power Systems Ltd personnel working under the direct supervision of REAL engineers.

3.5.3 Grid Connection

The grid connection to the project was provided by NORWEB plc. Further details are not available.

3.6 Operation Phase

Operation of the station was initially carried out by NORWEB Hydro personnel with maintenance support being provided by REAL and the equipment suppliers. Following approximately 18 months of operation, the scheme was sold to Power Systems Ltd who operate a portfolio of combined heat and power and renewable energy generating plant.

Full details of operating performance have not been made available however it is understood that the energy production from the project has not yet met the anticipated target. The reasons for this are understood to be a combination of the following factors:

- Low flows during first three years combined with leakage through the adjacent canal gates.
- Trash in intake.
- Unforeseen factors which have induced fatigue in the fabricated steel draft tube necessitating major repairs.

It is understood that the combination of these factors has reduced the output to around 70% of that projected by the feasibility study.

The first of these problems has arisen through the way in which the canal company controls the sluices and the leakage through them. The second has largely been overcome by installing a coarse screen in the approach to the inclined screen which keeps out most of the trash. The last has been overcome by a complete re-building of the draft tube and its supports. Latest information shows a clear improvement in energy production performance.

4. Conclusions

4.1 General Conclusions:

Following the research into the project and consideration of the information obtained, the following conclusions can be drawn:

1. The project was successful in initial stages in obtaining consents and the power purchase agreement. This initial success was largely due to the lack of any significant non-technical barriers to the project.
2. The construction stage of the project was a success from a technical perspective and demonstrated the benefits which can be brought to a project through a combination of innovation and experience.
3. The operational stage of the project has been less successful to date however recent remedial works have resulted in significant improvements in performance.

4.2 Examples of Good Practice and Lessons Learned

From the above, it is possible to cite specific examples of good practice which contributed to the success of the scheme and which are recommended for adoption in future developments. It is also possible to note areas which were less successful to assist the avoidance of future problems. These are as follows:

- Significant opportunities for economic development are presented by existing civil engineering works on Britain's waterways.
- In particular, canalised rivers provide improved opportunities for development due to the low environmental sensitivity;
- A combined approach to design and construction can produce significant savings. In particular the design of permanent works features so as to facilitate easier construction will produce benefits. This may require early discussions between designers and contractors;
- Significant costs savings may be available through employing a multi-procurement strategy with respect to the generating plant. This however requires specialist knowledge on the part of the developer or his project manager/designer.
- Trash accumulation can cause significant loss of revenue from low head plants on major waterways. The installation of an efficient trash screen cleaner is essential.

The above examples are discussed in greater detail within Section 1 of this report.