Best practices guide
For Small Hydro

SPLASH
Spatial Plans and Local
for Small Hydro

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INTRODUCTION

Hydro has been one of the main sources of power for 500 years and more and blossomed with the invention of the overshot wheel which efficiently converted the power of falling water to useful mechanical energy. There were literally thousands of small hydro power stations called water mills. The vast majority of these have now fallen into disuse, but the potential they represent is still there. Small hydro represents a small but secure and reliable source of energy that we should be using as part of our drive to promote renewable energy. However the transaction costs of realizing that potential are high and provide the major stumbling block in making use of this resource in our midst.

Small hydro suffers right from the start however from a problem of definition. What is small hydro? We know that it starts with as small a generator as you are able to use in practise. For some purposes – isolated locations with no possibility of mains supply, very small units of a few Watts may be practical and the most economic solution (although not cheap). But the upper boundary depends on the country and context. In much of Europe the boundary is taken as 10MW. But at this size, a hydro plant will almost always have some sort of environmental impact. Each organization or country has its own subdivision of small hydro. It is perhaps better to classify small hydro as follows:

- Large small hydro: 500kW to 10 MW
- Small small hydro: 100kW to 500kW
- Micro hydro: 1kW to 100kW

The number of sites using hydro power became quite significant in European countries following the invention of the water wheel and its refinement. These would represent a valuable resource even in today’s conditions. The power capacity that was still operating in water mills in Germany in 1925 for instance is comparable with the United Kingdom’s current wind power capacity.

As water wheels were replaced by turbines, and industry became larger and was served by regional and national power grids, many small hydro sites were abandoned in favour of the ease of a dependable power supply from the grid. Now there is a renewed interest in the small hydro sector as a contribution to the supply of electricity from renewables.

### Table 1: Some historical estimates of the number of water mills

<table>
<thead>
<tr>
<th>Date</th>
<th>Country</th>
<th>Estimated number of mills</th>
<th>Comments</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late 11th Century</td>
<td>England</td>
<td>5624</td>
<td>Not a complete survey</td>
<td>Domesday Book</td>
</tr>
<tr>
<td>1850</td>
<td>Ireland</td>
<td>6400</td>
<td></td>
<td>Reynolds (1983)</td>
</tr>
<tr>
<td>1850</td>
<td>Germany</td>
<td>40000</td>
<td></td>
<td>Reynolds (1983)</td>
</tr>
<tr>
<td>1925</td>
<td>Germany</td>
<td>33500</td>
<td>Power 560MW</td>
<td>Reynolds (1983)</td>
</tr>
<tr>
<td>Early 1800s</td>
<td>France</td>
<td>Over 75000</td>
<td>Still over 50000 in 1900</td>
<td>Ademe</td>
</tr>
</tbody>
</table>


**New hydro plant comes up against three major sets of obstacles.**

Firstly there is the economic obstacle that small plant is more expensive, euro for kW, than large plant and so has a longer payback period. This is aggravated by the high transaction costs of getting all the necessary permits, and/or covering the aborted costs of unsuccessful applications. This is generally proportionately much higher for small projects than for large since they usually have to go through exactly the same procedures.
Secondly there is the lack of certainty in being able to get a permit. In general small hydro plant that falls in the micro and small small hydro range does not represent major investment. Major companies are not interested in that range themselves and rely on small private investors to carry out such investments. For these investors, delays can represent major costs as they wait for investment returns to come in. For them certainty can make the difference between a profitable and successful investment and bankruptcy. However the process is extremely complex and usually requires several permits and a multitude of consultations.

Thirdly there is the perception that small hydro is like large hydro. Small run of the river hydro usually has minimal impact on the river regime and can use well established structures which have become integrated into the river ecosystem. It does not usually involve new dams or storage reservoirs and where there are existing structures, new provision can be made to allow the passage of migratory fish so ameliorating the situation. The application of the Water Framework Directive threatens to make the situation worse unless provision is made at the river basin planning stage to take account of the potential for small hydro and identify those locations where it is acceptable.

The SPLASH project was set up to try out one response to these problems. The objective was to prepare spatial planning documents to identify with some certainty those sites where small hydro is acceptable, and perhaps more importantly, those where it is not. The precise procedure was left to the partners, organizations in France, Greece, Ireland, Poland and Portugal. The context is different in each country and the solutions chosen are different in each country. As a support to this project a best practice guide was planned to look at existing examples of spatial planning for small hydro. In practice the survey found NO pre-existing examples of formal spatial planning relating to small hydro, and only a few examples of coordinated support for small hydro that could be referred to as planning in the wider sense. So the initiative presented in the SPLASH project really is a novel enterprise.

**REGIONAL PLANS OR LISTS OF ACCEPTABLE SITES**

Previous attempts to organize a spatial plan for small hydro have mainly been organized by regional government or utilities. Three such examples were found, one of which is described in a case study.

In India, one of the first UNDP GEF funded projects was the Hilly Hydro Project in India. In India the river is owned by the State Government which can therefore grant licences to establish plant. However there is a severe electricity shortage in India and the promotion of privately funded small hydro was seen as one solution. A list of sites available for development has been prepared by the State Government in Himachal Pradesh, and this mechanism has now spread to a number of other Indian States. But this list does not guarantee success in obtaining a permit – the developer still has the responsibility to obtain all the necessary environmental permits. (see case study)

A similar procedure was adopted in Navarre in Spain where the Regional Government wished to promote renewable energy as a tool for local development. A renewable energy company was set up by the region and prepared a plan for the development of renewables in Navarre. In total 25% of this was based on small hydro in this area in the foothills of the Pyrenees, and 75% in a programme for the development of wind energy. The plan was an effective promotional tool since the bodies responsible for approving renewable energy plant in Spain are the Energy Departments of regional government. Since the Department approving developments is that promoting industry, and the body preparing the plan is an establishment set up by regional government, the context is favourable for approval of proposals mentioned in the plan. However with the liberalisation of the electricity market, the utility has been restructured and energy planning has been outsourced to a successor consultancy. Both the utility and the consultancy have become much more business oriented. All requests for a copy of the plan met the reply that it was “commercially confidential”, which was a surprising response regarding a plan originally developed in the para-public sector. So it is impossible for us to assess whether this really is a balanced appraisal of the economic opportunities and environmental constraints or simply a development programme based on economic criteria.

Hydro British Columbia has prepared a guide to the development of small hydro in British Columbia, Canada. HBC currently produces 90% of its energy from hydro, but all comes from only 30 large hydro dams in the region. They now wish to diversify into smaller units. The utility prepared an inventory of 572 “micro hydro” sites in the range 0.1-5MW which can be considered and this represents the first stage in any appraisal of resources. Just under half of these sites are over 2MW and only 78 are below 0.5MW. Most sites are high head although a range of low head sites (in the BC context, below 30m!) are identified. The document identifies sites suitable for small hydro and estimates the potential resource, but is in no way a
formal spatial plan. Spatial plans have to be prepared in detail by the local authorities and “first nations” concerned in conformity with the Water Use Plan of the Government of British Columbia. The utility itself plans no further development of this inventory which is left as a resource for independent power producers who may wish to develop sites.

PERMIT PROCESSES FOR SMALL HYDRO

The body responsible for spatial planning control of small hydro development varies significantly between countries. A review was made among the partners in SPLASH to identify the body responsible for granting permits for small hydro plant. In a number of countries several bodies were involved and in most instances the key body is a national government organization.

The permit processes are long winded and, in many cases, expensive. The fees concerned in some countries preclude very small plant – for instance in Portugal an application involves a total of 2,650 euros plus an annual inspection fee of 250 euros plus a guarantee of execution of 5% of the cost of the total investment and a guarantee for environmental recovery of 2% of the cost of the investment. Similarly in Greece there is a tendency not to carry out very small investments due to the fees and procedures involved. In addition to the formal licences, many other bodies are formally consulted during the permit process and an objection from one of these can prevent a proposal being accepted.

A number of factors are of key importance in these procedures. One of these is ownership of the river – for instance in France hydraulic rights are national property and the préfet is able to grant permits on behalf of the state and control development in the river bed. Some mills operating at the time of the revolution in 1789 still possess a statutory right to use water however.

While the permit that is considered crucial to success is indicated in bold in Table 2 below, there are consultations between them and often it is impossible to proceed to one permit without first having obtained another. For instance it is futile to apply for planning permission in the UK without an offer of an abstraction licence. The Powiat will not grant a Building Permit unless the agreement is obtained from the RZGW in Poland.
Table 2: Simplified outline of permit processes in some European countries
(The most significant permit is indicated in bold)

<table>
<thead>
<tr>
<th>Country</th>
<th>Permits for planning and body responsible</th>
<th>Permits for water use and issuers</th>
<th>Other permits needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poland</td>
<td>WZIZT: Gmina Building Permit: Powiat</td>
<td>Regional Water Authority (RZGW): General approval. Operat Wodny Prawny: Powiat (District).</td>
<td>Operating permissions: RZGW, Gmina, Powiat. Electricity Connection permit (Regional Distribution Co.)</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Planning Permission: District/Unitary Authority</td>
<td>Abstraction licence: National Rivers Authority</td>
<td></td>
</tr>
</tbody>
</table>

Any spatial planning framework will need to influence the key decision makers – in general the body granting the permit indicated in bold in the above table. This is not always logical. For instance in Poland, the Operat Wodny Prawny granted by the powiat (district) would be the obvious document on which to base a rational spatial plan and could be prepared in cooperation with the RGZW so that it was consistent with RGZW policies. However the consent of the RGZW is the critical consent since the RGZW offices generally wish to keep control of information linked to the use of water (which is a valuable commodity). The consent of the Powiat is simply a rubber stamp.

**CASE STUDIES CHOSEN**

There are a series of objectives involved in the planning process, and each will have a different priority in different countries.

The prime reason small hydro is currently being promoted is a desire to reduce carbon emissions and limit the impact of energy use on climate change. Small hydro cannot solve climate change of itself, but as part of a coordinated energy strategy it can make a significant contribution.
Most of the other objectives for developing small hydro are not linked to the environment. They mainly represent objectives related to the promotion of development. They are primarily linked to easing the process of granting development permits by:

- identifying acceptable development sites
- Aiding developers to cooperate to install development that would otherwise not prove a viable proposition
- Identifying constraints
- Promoting community groups investing in renewables to avoid NIMBY* reactions
- Incorporating small hydro in programmes designed to promote local economic activity or protect cultural heritage.

Often the economic development implications are the key factor. They may therefore prove more important than the energy produced per se. In Portugal and Poland for instance, the tourism and heritage benefits from the renovation of historic mill sites were the major stimulus to restoring small hydro sites, while in Ireland by contrast, fear of an impact on the angling industry – one of the motors of Ireland’s tourism industry – was a major constraint.

One motivation that proved quite strong in Northern Europe was the desire to help private owners of very small sites restore their mills as attractions or for their own pleasure of seeing them fulfil their original function as sources of energy. This objective is as much cultural as energy related but can provide a supporting objective encouraging action that is otherwise of marginal economic viability.

As explained the examples chosen really selected themselves due to the lack of other systematic approaches to small hydro from a regional planning perspective prior to SPLASH. They represent different approaches to the problem related to different cultures. In total there are 9 case studies, representing 9 very different approaches. The original concept of a broad based supplement to the development plan was only followed in two cases.

The approaches fall into several broad classes (not mutually exclusive) which are described in Table 3:

**SUCCESS OF THE DIFFERENT APPROACHES**

One striking feature of all the projects is the time taken to go through the planning process. Success is dependent on having a supportive administration that will maintain resources over a prolonged period of time. This inevitably needs cooperation between different central and local government structures and depends, in particular, on the enthusiasm of a key person in the structure. Without such a motivator one can anticipate the programme dying of exhaustion before any results are announced. From this point of view, a long term source of funding can be of tremendous support. The funding provided by GEF in the Indian State of Himachal Pradesh can act as a model.

All the SPLASH partners had problems with getting support from the local authorities concerned. The French project was developed in the PNR Mont Pilat because the Pilat had already shown an interest in small hydro. The Polish partner concentrated on the Prądnik river valley following up the enthusiasm of one local authority, Sułoszowa, and working with the Ojcowski National Park. They initially found no interest in the water agency in working on the Sreniawa and Stradomka Rivers, both of which could offer more potential. The Greek partners originally planned work on the River Ardas, then the Vegoritidis Basin, but could not find enthusiastic local authorities so returned to the Axios Valley where the municipality of Agios Athanasios showed continued interest. It was only in Ireland and Portugal that the local authority structures were enthusiastic from beginning to end.

This is an important lesson for policy planning. It is clear that one cannot rely on the enthusiasm of local authorities themselves, which will not see planning for small hydro as a priority unless there are clear local economic benefits, or unless there are obligations placed on them at national level. With the introduction of the Water Framework Directive, matters will become even more complicated and it is a matter of some urgency that action should be taken to integrate small hydro potential into river basin planning. It is worth repeating that this needs direction from Government if most local administrations are to take it seriously.

* NIMBY : Not In My Back Yard – i.e. not near me.
### Table 3: Broad approaches of the case studies

<table>
<thead>
<tr>
<th>Methodological approach</th>
<th>FR</th>
<th>GR</th>
<th>IRL</th>
<th>PL</th>
<th>P</th>
<th>INDIA</th>
<th>UK (SS)</th>
<th>UK (Tin)</th>
<th>USA</th>
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<tr>
<td>Inventory approach (&quot;Bottom-up approach&quot;)</td>
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<td>Weighting of constraints and multicriteria analysis</td>
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<td>River owned by State</td>
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<td>Institution is site owner</td>
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</table>
Another approach that has shown real promise is action to promote cooperative development of small generators in former mills. There were very many water mills in all European countries many of which only fell into disuse in the last century. Where sufficient structures remain, they represent a real opportunity both to restore local heritage and to generate small amounts of green electricity. Someone who buys a mill usually does this because they are interested in the mill and its history. Others who inherit a mill are interested in the link with their family. For a whole series of personal reasons, there is enthusiasm which asks to be tapped. The pioneering project in Somerset has spawned other copies in the UK and has formed a model for the project in Poland. The interesting point here is that there is a real need for a “leader” to carry forward such a project from design to completion on behalf of a group of interested and committed volunteers, a role that is particularly well suited to project officers working in local authorities who know how to cut through the swathes of red tape.

In Portugal the programme to restore mills for tourism purposes is more directly led by local authorities, but has the same objective. A similar objective of the project in Pilat is the promotion of tourism linked to the “white coal” industrial era. The real advantage of this approach is that it is multi-objective. The amount of electricity generated is in any case limited: in Pilat it is 1.1MW all told, in Somerset the capacity of all the sites combined was around 150kW maximum and the potential was 100kW for the proposed Cultural Park on the Prądnik in Poland. Mills are not just restored for electricity generation but the generation forms part of a larger heritage and tourism objective.

**Mapping the Potential**

The projects have been ingenious in developing systems of appraising sites worthy of development. Three different approaches to sieve mapping have been used.

Cork sieved out sites on a map base using actual surface areas and assumed that sites identified as of conservation interest could not easily be developed. This forms a stark contrast to the situation in Poland where the sites are located in a National Park, to Portugal where they are located in a site placed on the UNESCO World Heritage list, and to France where they lie in a Parc Naturel Regional. Planners like simplicity and have a tendency to exclude anything that could cause problems. In Ireland small hydro comes up against the opposition of fishery and archaeological heritage interests, but these are not necessarily insurmountable constraints.

Portugal used a similar approach of plotting a series of constraints onto a map base. However, unlike Cork, it had the advantage of a limited range of potential sites since the seasonal flow found in Portugal’s rivers limited potential development to the four main rivers of the study area and meant that the fishery interest of the area was minimal. In practice, because the project examined a series of former mills in the study area, the appraisal ended up as a series of site investigations for mills that could potentially be restored.

Greece prepared weighted maps based on 50m x 50m grid squares to identify areas of search for sites and transposed this onto a map of the river network using multi-factorial analysis. This method will work well provided the “pixel” is of a “fine grain” character, but will have limitations if the grain is too coarse. The use of a 50m x 50m base, is therefore an important consideration. Small hydro is based on actual sites and the method has to be able to handle these. The method proved successful in identifying 10 potential sites on the Axios River Basin.

France used a weighting system to evaluate river systems and applied it over linear stretches of river. The factors were linked to the river itself and were directly related to its ecological value and suitability for small hydro, and could be appraised separately if needed. This is a logical approach to a linear resource and has much to commend it. The weighting system was checked and rechecked with experts and national and regional authorities to ensure that there was expert agreement on the weights chosen and the sieve screens used. In practice the French came down to assessing potential sites, and the final plan became an evaluation of 50 identified sites in the study area.
Both these last two approaches used a weighting system which is the product of the priorities of the culture where and the time when it was devised. While legal constraints are objective limitations and may preclude development, weightings and evaluations of the degree to which other factors may preclude development are necessarily inherently subjective, based on value judgements. This is not a criticism, but rather a factor to take into account when evaluating the results. There is a key issue about the public acceptability of the system by which weights are determined – have the key bodies involved in assessing what factors should be sieved in or out or in assessing the value to be given to them got legitimacy and respect. In this matter, the French system – which went through a detailed process of consultation with the relevant official expertise when determining the weights – has much to commend it.

The output of all these approaches was a plan that identified acceptable areas where small hydro could be considered and those areas where it was either only possible with major constraints or simply not acceptable.

**Weaknesses of the Projects**

A number of benefits anticipated from some of the projects as a result of the community development approach have not in practice proved justified. They include the following anticipated advantages:

The Somerset project had hoped to obtain a better sale prices for electricity by selling the production from a number of mills or suppliers jointly. A favourable tariff was obtained (so that it was profitable to sell the production and buy electricity back in more cheaply). However the amounts involved have proved small and the benefit is debatable. It will have no impact in those countries with a feed in tariff (e.g. FR).

It was thought that applying for permits together would reduce transaction costs. Since it was anticipated that many would be similar, it was thought that this could offer some significant savings. In fact the partners have commented that each plant has always to be considered on its merits. However it is to be assumed that the cost of finding a site will be considerably reduced by such a plan. The more detailed and specific a plan is, the more money can be saved.

The development of a plan depends on political willingness. As always this is not present in all authorities all of the time, and the selection of really committed authorities is likely to be a key factor in success.

Likewise the degree to which the consultation process involves the various interests varies considerably. In general the willingness of different administrative structures to cooperate to prepare a joint policy programme is heavily associated with the political cultures in the countries concerned. Public administrations have a tendency to be riven by rivalries over control over territory (both physical and intellectual). Cooperation needs a hook to hang itself on, and preparing a joint policy statement on small hydro could provide that hook. But as the difficulty of involving the Water Agency in Poland demonstrated, cooperative working cannot be taken for granted. Bringing partners together to prepare a joint plan would encourage cooperative working and ease the development of jointly acceptable policies.

Little assessment has yet been made of the impact of the planned development in terms of climate change and socioeconomic effect. This needs development as the projects continue.

In addition there is great variation in the degree with which external interests (associations, individuals) are involved. The French plan has been led by administrations and primarily involved public structures. The British work in Somerset has primarily involved members of the general public steered by a local authority. These approaches represent opposite ends of the spectrum. For success it is necessary to carry both public and private structures along. Naturally in pilot projects various approaches have been tried. The experience of the examples in this guide can form a basis for getting the balance right in future projects.

**Needs and Recommendations**

If the regional plan approach is adopted, then there is need for a strong lead partner in order to get the policy applied on the ground. Ideally this should be the body responsible for the key permits or decision making. Often this is the water authority, but it may be the planning authority or regional arm of the government...
department. What is vital however is that they see that there is a need to be met. The larger the scale, the greater the chance that a comprehensive approach can be adopted. There are strategic advantages in considering sites on the basis of a water catchment. In France and Greece, higher level administrations (Department, region) have significant power and might provide a suitable structure to promote planning.

Against this must be set the fact that small hydro sites are local in nature and therefore a local approach is ideal if one is approaching the planning process from a local or community development perspective. For this there are benefits in approaching planning on a smaller scale since it will be easier to involve people in the community development process.

In Ireland and the UK the large size of the local government units may provide the advantage of both proximity and coverage at a river basin scale. However in the actual quality of the plan, nothing can substitute in the long run for the enthusiasm and a tradition of cooperative working as found, for instance, in North Portugal.

It needs to be remembered that small hydro can have negligible impact on the environment, especially when it is grafted on to existing civil engineering structures. It is not large hydro. Great circumspection should be taken about excluding areas as completely unsuitable for small hydro on environmental grounds although some may be much more sensitive due, for instance, to the natural interest of the area. As noted, some of the sites in other projects are chosen because those responsible for managing areas with protective designations are interested in using their resources of clean energy.

The Water Framework Directive is currently in the process of being implemented in the EU. It will have implications for small hydros since there is likely to be fear that small hydro will impact ecological status. Adequate provision needs to be made in river basin management plans (and this could provide the cornerstone on which to build small hydro planning documents), but this will only happen if there is a lead from above. They could use one of the models described here and this might lead to a blossoming of small hydro in the areas concerned. The situation in France for instance looks quite promising. However in the absence of such coordinated policy-making, it would be likely that each and every proposal for small hydro will come up against many barriers on the road to getting all the necessary consents and this has caused considerable concern to be expressed by small hydro interests. The European Commission has taken this issue to heart and DGENV is establishing a strategic consultative group on hydro power issues and the WFD.

If a community development approach is adopted, as in Somerset, Tintern, Poland and Portugal, it is vital to have an enthusiastic and self sufficient project leader with long term security who can enthuse people and cut through red tape. Community development is not cheap. It is very expensive in staff time and working with groups of local residents on renewables is no exception. However such time is needed if one is to successfully weld small individuals together so they can work in a group on a project that, in this instance, is rarely their main livelihood. Such an approach also lends itself to support from European Union funds for rural development which are receiving some priority in the transformation of the Common Agricultural Policy.

The smaller the scheme, generally, the longer the payback. Some of the micro hydro schemes have extremely long paybacks and if this is the case, it is particularly important to target other benefits. Ultra small hydro schemes are never going to compete on the basis of price, so it is desirable to target the combined benefits of an integrated programme, as in Poland and Portugal.

Finally, to date, joint working has brought few benefits in improving arrangements for connection to the grid. This needs attention. In general it is recommended that there be national conditions of connection, especially for very small sites. A particular issue for micro hydro is the introduction of net metering for very small customers (e.g. under 100kW). Under net metering, the electricity bought from the grid is deducted from the electricity sold to the grid, and a payment is made (either way) for the balance. In view of the small total load involved with micro hydro, this is unlikely to have any serious impact on grid stability. But it would ensure that the retail price for electricity is the effective value of the electricity to the consumer who is also a producer.
Planning for Small Hydro

Boulder Colorado
(USA)

GENERAL ASPECTS

Boulder is a city of 125,000 Residents situated at the foot of the Rocky Mountain chain in Colorado.

BACKGROUND

Boulder’s water supply comes from an altitude of 3000 m in the Rocky Mountains and is carried down to Boulder, 1300m lower down, in a forced conduit. In such mountainous territory both the treated supply itself and the raw water supply is under considerable pressure which has to be released at intervals. This provided the opportunity to generate energy.

ACTION

Boulder investigated the opportunity to use the surplus pressure in their supply network to generate electricity in the mid 1980s. A plan was developed to install 5 small hydroelectric plant in the supply network – four for the treated water supply and one in the raw water supply and generate a total of 4.1MW of electricity. Following a review of the system, two further generating units were installed in the raw water supply at Silver Lake (photo) and Lakewood in the early 2000s increasing the total capacity to 11.1MW. On treated water lines these are generally Francis turbines while on the main raw water supply these are Pelton wheel impulse turbines, in two locations in the treated water supply the generators can also act as pumps when needed. The income amounted to $1.7M in 2004 – nearly two thirds coming from the capacity charges and only one third from the current. The payback time varies from 2.5 to nearly 10 years, apart from one plant which has the relatively high payback time of nearly 28 years. In 2001 the city bought the Barker Canyon Hydroelectric facility, originally built in 1909-10, for water supply purposes. However this is also continuing to generate electricity but with greater priority given to environmental criteria (e.g. restoring a reserve flow below the dam). In total about 41GWh of electricity was generated in 2004.

The plant has a number of advantages, apart from the increased income for the water supply utility which enables it to replace outdated plant. In particular the equipment reduces air entrainment in the supply pipeline. A replacement pipeline is planned in which the pressure arrangements are being designed with the generation of hydroelectricity in mind at the pipe outlet.
<table>
<thead>
<tr>
<th>Hydro Station</th>
<th>Water source</th>
<th>Turbine &amp; generator</th>
<th>Power (kW)</th>
<th>Annual gen. (GWh)</th>
<th>Approx. Payback</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxwell</td>
<td>Treated</td>
<td>Francis, induction</td>
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<td>5.3 yrs</td>
<td>Also pump</td>
</tr>
<tr>
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<td>Francis, induction</td>
<td>136</td>
<td>0.6</td>
<td>8.5 yrs</td>
<td>Also pump</td>
</tr>
<tr>
<td>Orodell</td>
<td>Treated</td>
<td>Francis, induction</td>
<td>180</td>
<td>0.8</td>
<td>27.7 yrs</td>
<td></td>
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<tr>
<td>Sunshine</td>
<td>Treated</td>
<td>Francis, induction</td>
<td>800</td>
<td>4.1</td>
<td>6.2 yrs</td>
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<td>Raw</td>
<td>Pelton, synchron.</td>
<td>2.9</td>
<td>9.0</td>
<td>5.9 yrs</td>
<td></td>
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<tr>
<td>Silver Lake</td>
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<td>3.5</td>
<td>17</td>
<td>8.8 yrs</td>
<td></td>
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<tr>
<td>Lakewood</td>
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<td>Pelton, synchron.</td>
<td>3.5</td>
<td>19.6</td>
<td>2.7 yrs</td>
<td></td>
</tr>
</tbody>
</table>

*Hydro generation network in Boulder, Co.*

**EVALUATION**

A number of local authorities have identified water supply as a potential source of electricity – a small compensation for the large amounts of electricity used by many lowland local authorities for water pumping. Examples can be seen in high mountain areas in Europe as well, for instance in the City of Martigny which also has heads of 1,000m or more. However it depends on there being sufficient surplus pressure and the amount generated in lowland areas may not warrant the investment. Nevertheless the example of Boulder demonstrates the value of regarding this in a comprehensive manner. The advantage of using water that has already been abstracted is that the additional environmental impact is usually restricted to a small powerhouse (since most sites already have a grid connection and there is no additional abstraction from the natural watercourse) and most of the civil works are already in place – they form part of the water supply network. However not all the pressure can be used, and investment needs to be planned as part of an overall arrangement to ensure that the optimum result is obtained.

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Photo credit: City of Boulder Utilities Division.
Planning for Small Hydro

Central Macedonia (Greece)

**GENERAL ASPECTS**

Greece has a burgeoning demand for Electricity, but most electricity is currently generated from poor quality coal. Hydroelectricity represents a possible alternative resource, but methods of appraising acceptable locations are desperately needed.

**BACKGROUND**

The consultancy Alpha mentor has worked in collaboration with the consultants HYETOS and DND and the Regional Council of Central Macedonia to develop a set of policies for small hydro on their territory. Most potential occurs in rivers which rise in the mountains of Northern Greece and the adjoining states of Macedonia (FYROM) and Bulgaria. Experimental approaches were adopted designed to apply multi-vector analysis of a river basis and to prepare a feasibility study of a low head small hydro site on an irrigation supply dam on a major river.

**ACTION**

The North Vegoritidis basin was chosen to demonstrate the potential of multi-vector analysis. This basin of 771km2 lies North-west of Thessaloniki and acts as a closed hydrological basin feeding Lake Vegoritidis. The level of this lake has declined from 546m a.s.l. to 510m a.s.l in recent years due to intensive use for irrigation (and water has been drawn off the lake in the past for hydropower purposes at the Agra power plant). The water in the area is already subject to pollution and the Greek Government has been subject to warnings issued by the European Union due to the poor water quality in the Lake. The water bodies in the area are of high ecological value and are designated under European Union Directives.

The method of analysis is a computer adaptation of the traditional sieve map approach to strategic land use planning. In sieve maps, areas are mapped on a grid overlaid on the study area. Grid squares on transparent overlays can either be allocated a weighted value or excluded from the analysis if a factor completely precludes development. Weights for individual squares are then added up to give a graphical evaluation of the suitability of a given square for development.
Such a system is perfect for adaptation to GIS mapping. In multi criteria analysis different criteria are used to assess suitability of the area for small hydro development. A special GIS application was therefore used to analyse the Vegoritidis Basin to create a grading system capable of rating the suitability of sections of rivers in the basin for use for small hydro generation. Different layers of information are applied to the plan in succession and can be combined to give an overall integrated estimate of suitability. Analysis was made using a grid of 50m x 50m squares which produced a very fine grain map.

The analysis applied depends on the factor being considered – in the case of the presence or not of a water course (left), the factor is a simple 1 (present) or 0 (absent) in the square concerned.

Where the locational factor has a measurable impact, as in distance from an electric grid, then a weighted figure can be applied as in the chart below.

A wide range of factors were considered over the whole 771km2 of the Vergoritidis basin. These included the following:

<table>
<thead>
<tr>
<th>Watercourse network</th>
<th>Protected Ecosystems</th>
<th>Military facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slopes (above left)</td>
<td>(above right)</td>
<td>Major structures</td>
</tr>
<tr>
<td>Height</td>
<td>Forests</td>
<td>Coal mining areas</td>
</tr>
<tr>
<td>Roads and railways</td>
<td>Urban areas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Archaeological sites</td>
<td></td>
</tr>
</tbody>
</table>
These were integrated by an analytical calculation and this produced a final appraisal of the suitability of the water-course network for small hydro (left). This is presented graphically so that the most suitable sections of river appear a brighter colour on a computer generated map. (See below)

**Application of the Plan**

In Greece applications for small hydro plant are considered by applications for the three licences needed by a small hydro plant, the Electricity Generation Licence, the Installation Licence and the Operation Licence. The installation licence, which has a life of two years, is the one that creates the bulk of the problems. The RES installation licence application is made to the regional authority and the process is very complicated, taking about 1 to 2 years to complete, requiring the official approval of the proposal of about 40 public-sector entities at central, regional, prefecture and local levels. It needs to be checked, in terms of conformity, with 4 National Laws and 7 Ministerial Decrees. The transfer to the regional authority, designed to simplify the process, has not really helped since the local level has no specialist expertise in this field.

The consultation procedure with interested bodies which takes place during this procedure of applying for a licence, is very time consuming and expensive. The GIS provides a framework to identify areas considered suitable by these interests and to eliminate those that create the most intractable problems. It can enable the interested parties to respond quickly and accurately to request for proposals.
EVALUATION

The evaluation of the Vegoritidis Basin was prepared in cooperation with the local Office for the Development of Water Resources and two local municipalities. However when it came to taking the development beyond the simple appraisal of a computer generated map, no local interests were willing to invest time and resources into identifying locations for small hydro plant. It simply did not have the political weight to generate interest among the local elected members.

This demonstrates the importance in the plan making process of a real political commitment. With all the data one could possibly ask for (for this area was heavily studied on account of the pollution problems in the internal drainage basin of Vergoritidis), it still proved impossible to prepare a guidance document due to lack of interest at the municipal level.

FURTHER ACTION

Therefore the partner consultancy in the SPLASH project cooperated with the Agios Athanasios municipality in the Axios River Basin. This municipality is interested in the promotion of small hydro in its area and will provide the local commitment to make such plans work.

The same appraisal approach developed for Vergoritidis was applied in the Axios River basin (right). The Axios River arises in FYROM and the majority of its catchment is there – only a 701km² of its 23,747km² catchment, including its delta, lies in Greece. The flow in the Greek part of the catchment – near the river’s mouth, is of the order of 120m³/sec. A multi-criteria analysis was carried out on the Greek part of the basin and in total 10 sites were identified.

The document thus produced cannot be a formal plan since planning for small hydro in Greece is carried out by central government. However, providing it has the support of local and regional authorities and the Water Agency in the target area, it can hope to provide a framework to guide developers and set a context for decisions by the national decision making authorities. It is hoped that this technique will be adopted throughout Greece to identify areas worthy of further detailed study to find small hydro sites.

One of the ten sites identified, the Ellis Dam, was far more attractive than the others and has been the main focus of attention. This dam, which lies on an irrigation canal within the Agios Athanasios municipality, handles one third of the flow of the Axios River. A detailed feasibility study was carried out on this site and a 3.5MW turbine on a 12m head is proposed.
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Photo credit: Prefecture of Pella.
Planning for Small Hydro

BACKGROUND

As its contribution to the SPLASH project, the Cork County Energy Office planned a local plan for the Blackwater River. The majority of the catchment of this river falls in the County of Cork and it is a river that is highly valued for its fishery, so providing a good example of the conflicts that arise from its use for fisheries and for power production.

ACTION

The first task identified by the planners was to establish a database of information to eliminate unsuitable locations. A specialist GIS was put in place to sieve out sites designated for specific valuable characteristics. Areas of high nature conservation value were identified and these included Special Areas of Conservation (SACs), Natural Heritage Areas (NHAs), Special Protection Areas (SPAs) and Scenic Tourist Routes or Scenic Landscape Areas. Mills or Weirs on the National Monument Register were also recorded. Not all of these preclude development but may imply more stringent constraints. Additional information on the grid network, fisheries quality was also searched for. However this information was difficult to obtain and there was an initial inflexibility in the response of the relevant bodies, perhaps the result of apprehension on their part. For instance a draft appraisal of rivers by the Fisheries Boards in Ireland was still under consideration and it was not at first available for formal release to the planners. In addition the Department of Heritage and Local Government refused to grant any consent for power production on former mill sites whatever the impact or lack of impact. A further very significant constraint was that the electricity distribution enterprise would not release a map of the low voltage distribution network so restricting the ability to take connection costs into account in the planning.

In order to evaluate potential sites an Excel based calculator was developed. A regionalized flow duration curve for the Blackwater was used as a basis for calculating potential power production from sites in the catchment. A limited amount of data was entered into this calculator: the region, the catchment area, the annual rainfall, the height difference between abstraction and water return, size of headrace or penstock, turbine type, gearbox type, and transformer type. This gives an estimate of the potential power output and annual electricity production.

GENERAL ASPECTS

The Blackwater is a river in County Cork in Southern Ireland. The river has a number of weirs at former mill sites within its agricultural catchment. There are several small market towns along its course, including the town of Mallow where the Cork County Energy Office is based.
An estimate of the total small hydro potential of Ireland was made in 1985 and this provided a first estimate of the sites available. This was supplemented by an estimate of the renewable energy resource in Ireland made in 1996. These sites were also entered on the plan.

A problem arose however in publishing information in this GIS in map form. There is copyright on the national Ordnance Survey of Ireland and the results cannot be published in paper form. However there is no problem in publishing this on the web as a web based map and it is planned to publish the plans on the web. An excerpt from the GIS sieve map is presented below.

As a follow on to this, a feasibility study was carried out on the Glen River site on the Blackwater. A second feasibility study was planned to make use of pressure reduction in the public water supply to Newmarket, a small market town in the Blackwater catchment.

A widespread consultation was carried out with interests directly involved in water management and heritage. The consultation was also put on the Cork County Council website from June-December 2004 and comments were requested from the general public. The responses received were overwhelmingly from fisheries interests. One of the big problems is that hydro in County Cork is viewed in the context of the Lee large hydro scheme, constructed in the 1920s which flooded a significant area of land and which is generally seen as having a major environmental impact. The potential small hydro sites on the Blackwater have no parallel with this and are predominantly run of the river sites with no new impoundment works and limited or no impact on fisheries provided suitable precautions are taken. In time the consultations with the different interests resulted in a greater understanding and informal consultations with the Fisheries Board proved particularly helpful in evaluating areas where there were unlikely to be major objections. Over 200 potential sites were finally identified within the catchment.

The plan when completed will be adopted as supplementary guidance and integrated in the full plan at the next development plan review in 2009. This is a much simpler process than trying to amend the development plan straight away and was also the approach adopted for their strategy for wind energy.

**EVALUATION**

Cork County Council has the great advantage that it is the one local authority responsible for the greater part of one catchment, with a responsibility for water management and water supply as well as development planning. Therefore it has a real potential to plan for small hydro on an integrated basis. Thus they have been able to succeed in progressing with the plan without the need for cooperation between a large number of authorities. However there was a major problem of getting the relevant information. In particular the electricity utility, a government owned body, would provide information on the grid connection possibilities by survey for any specific site, but was not willing to provide plans of the low tension network as this was seen as commercially sensitive!
The one factor that also is demonstrated is the difficulty of challenging other interests. Both heritage interests and fisheries interests were wary of development and seemed likely to present objections. So instead of preparing policies that give guidance on how these constraints might be overcome or circumvented, these interests have a tendency to present immediate and general opposition to all forms of new development, as for instance is the case on old mill sites (which are man made and have themselves evolved over the centuries).

However following the Cork County Council’s involvement in SPLASH, the Fisheries Board negotiated with the County Council and finally agreed to provide an analysis of the rivers in County Cork on the basis of their suitability for small hydro, graded from 1 (easy to integrate) to 5 (no development can be envisaged). The State Heritage Board is considering the implications of development on mill sites in the catchment and will indicate the degree to which new investments can be considered which utilise former mill structures.

Many of the locations identified in the plan are existing sites and sites identified in previous studies. A project proposed for a feasibility study, at Glen River, was actually a new development on a steeply graded section of river rather than a mill site. Thus there clearly is scope for the development of new locations and this needs an appraisal method that identifies those sites likely to be suitable for run of the river developments using, for instance, criteria such as river bed gradient.

This plan is a first, a comprehensive planning document prepared on a river catchment basis. No other local authority has prepared a development plan, even as planning guidance, on the scale of a river basin. Such an approach is an essential response to the Water Framework Directive if the potential of rivers for generating sustainable energy is to be reconciled with the need to protect their naturalness and ecological quality.

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Assistance provided by Cork Energy Office.
Planning for Small Hydro

Himachal Pradesh

(India)

GENERAL ASPECTS

Himachal Pradesh is a state in Indian Himalaya notable for its fine scenery. It has a large small hydro potential as yet largely undeveloped.

BACKGROUND

Hydro in India has been in continuous development, but its contribution to electricity generation has not kept up with the expansion of electricity generation generally, its share of total generation falling from 50.6% in 1963 to 44% in 1970 and 25% in 2003. To counter this trend the Indian Government has established a Ministry of Non-Conventional Energy Sources (MNES) in 1989 and transferred responsibility for a programme of small hydro up to 3MW to this new Ministry. Since 1999 this Ministry has been responsible for hydro up to 25MW capacity. Under its aegis, the small hydro sector has increased from 63MW installed capacity in 1989 to about 400 MW in 2004 (up to 3MW station capacity) and 1633 MW up to 25MW station capacity in 2004.

The National Hilly Hydro Project

The Hilly Hydro Programme was actually designed before the MNES was established. It became the first UNDP/GEF funded programme in India when the project was initiated in 1992. The MNES has been responsible for this project, formally called ‘Optimising Development of Small Hydro Resources in Himalayan and Sub-Himalayan Regions’ which has run for over 10 years. Initially neither the MNES nor UNDP/GEF had much expertise in small hydro development but they continued to give support to a small hydro programme and involved the newly established research centre, AHEC Roorkee.

The project was formally approved in 1994 by which time the installed capacity of projects up to 3MW had risen to 110kW through the completion of a number of old projects and developing a number of new one.

The project involved the preparation of Zonal Plans and a Master Plan for the key Indian States of Arunachal Pradesh, Assam, Bihar/ Jharkhand, Himachal Pradesh, Jammu & Kashmir, Manipur, Mizoram, Nagaland, Sikkim, Meghalaya, Tripura, Uttaranchal/ U.P. and West Bengal.

The execution of UNDP-GEF Hilly Hydro Project actually started from January 1995. The first year was spent in identification of National and International Consultants for various activity blocks, drawing terms of reference and contracts for them and formally appointing them as consultants. A baseline study was made of the ability of the infrastructure of all the 13 States to take up SHP projects.
It was proposed to set up 20 demonstration projects via the project which would use different commercially viable and environmentally friendly types of technology. These were to be evaluated for their environmental impact. Based on available information on potential SHP sites about 80 sites were short listed covering all the participating States. Available hydrology data and other details were collected. Based on this information about 50 of these sites were again short-listed. Most of these sites were physically visited by teams of national and international consultants and a final list of 30 potential sites for demonstration projects was drawn up. The main parameters considered in preparing this list of sites was the size of project, the possibility of community participation, preparing a selection of different types of location and hydrology, differing ownership models etc. No environmental studies were done during this stage of the process.

Parallel to this process other action was also undertaken. The project promoted the development of new and efficient designs of water mills, the promotion of low wattage appliances, and the establishment of different community participation models in three existing SHP projects. These projects were completed by the end of 1997.

To further promote small hydro, the MNES has encouraged private sector participation in hydro generation. The Ministry set a series of demonstration projects to show that small hydro could be commercially sound and environmentally acceptable. The Government obtained confirmation for the individual states that they would contribute capital grants of up to 50% of project costs and a list of 23 demonstration projects was agreed including at least one project from each State.

However this list was later amended as some States did not make good on their promise of finance, and/or limited interest on their part. Environmental Assessments and environmental improvement plans were prepared for each proposed project following detailed visits by the consultants. The majority of their recommendations were followed in the implementation of projects. AHEC was appointed to provide monthly monitoring of the programme.

Zonal plans for all the 13 States have now been completed identifying 2,162 potential sites of 3,827MW aggregate capacity, classed according to capacity and head. A Master Plan has been drawn up covering the participating States in order to develop the SHP potential identified in a systematic manner over the next 15 years. More detailed strategies at State level have also been suggested.

MNES has encouraged private sector participation in the small hydro sector, and provides “soft” loans to potential investors. (These are provided though the Indian Renewable Energy Development Agency IREDA which has so far approved support to over 123 SHP projects with a capacity of over 430MW. The total cost of these projects is INR 17,800 million and IREDA has given a loan of INR 9702 million (USD 1 = INR 47).

**ACTION**

Himachal Pradesh State lies in the Indian Himalaya and has great potential for hydro power. It has been one of the states that has most actively implemented the Hilly Hydro programme and provides a demonstration case of what can be achieved. A methodology was developed to identify potential sites using available hydrological date, topographical maps and satellite information. This identified over 2000 potential sites in the Himalayan and sub-Himalayan Region. Software (called HydrA-HP) was prepared by the Alternate Hydro Energy Centre in Roorkee, India and the Centre for Ecology and Hydrology in Wallingford, UK. This has prepared a model of river flow in the water courses in the state and provides a rapid means of estimating the hydropower potential of any location in the State. The programme allows one to identify the best sites and make rapid comparison of the applicability of different turbine types and their power output and reduces the initial expenditure on hydrological surveys.

The State Energy Development Agency, Himurja, has been given the authority to develop 5 MW directly in hydro develop projects.

Historically most electricity has been produced by the State utility since it is the State which owns the bed of the river and the water in it and grants the right to generate. However Himachal Pradesh is one of 15 States that have announced policies to promote private sector involvement in the generation of electricity. A model power purchase agreement has been prepared and agreed so that the developer has some certainly regarding the level of revenue to be expected. Today the State utility is purchasing power @ Rs. 2.50 per unit from private sector SHP projects.
A "shopping list" of sites has been prepared and offers are invited to develop sites on the list. While these sites do not come with any permits for development, the sites have been identified by a process that takes into account environmental impacts and economic feasibility and so in principle, this should have sieved out controversial sites and left only the most appropriate developments. Himachal Pradesh has offered about 469 sites with an aggregate capacity of 720MW. Memoranda of understanding have been signed for 217 projects representing about 347MW, which represents about half the potential small hydro resource in the State (Total 750MW). In total about 53 power purchase agreements have been signed.

Examples of projects supported under the programme indicate that the hydro programme could be very attractive to business interests.

**Solang**

SHP at Solang has a capacity of 1MW, and is run by a local business conglomerate of Himachal Pradesh origin. It had a "soft" loan from IREDA at an interest rate of 16.5% over 10 years. The interest was further subsidized by the UNDP-GEF Hilly Hydro Project with interest up to 10%, the developer only paying the excess. The developer can offset their own power consumption at Rs. 3.10/kWh instead of selling to the network compared to the feed in price of Rs. 2.50 (and the average purchase price at which energy is bought by the utility of Rs.1.34). The actual cost of production is Rs. 2.3 per kWh plus a 2% transmission and distribution charge.

**Raskat**

This 800 kW unit was the first plant to negotiate a long term power purchase agreement with HPSEB which has been the model for all subsequent ones. It was developed by a local investor. The rate, Rs 2.50 per kWh, is higher than the average procurement cost but not as high as the rate recommended for renewable energy. The long term power agreement enabled the developer to get subsidized credit from IREDA, and UNDP-GEF Hilly Hydro Project and at the same time the Government of Himachal Pradesh waived water royalties for 15 years as an incentive.

The strong local roots of the developer in the region and the employment of two of the developers personal employees with roots in the region developed a strong sense of local pride. This has been a major factor in its success.

**Titang**

This 800kW SHP project is the first project in the country set up by an NGO name Sai Engineering Foundation. The NGO has deep roots in Himachal Pradesh and also has technical strength to set up SHP projects. The project has been supported by UNDP-GEF Hilly Hydro Project on the similar terms as Solang and Raskat with loan from IREDA. They have power purchase agreement with HPSEB @ Rs. 2.50 per kWh. The project is providing power to remote villages in the Titang area.

**Kothi**

This 200kW plant has been developed by Himurja, the State Energy Development Agency. This is viewed as a purely demonstration plant, and, since both Himurja and HPSEB are owned by the state, no revenue is charged to the state. It only operates at a 30% load factor. The cost of generation is quoted at Rs. 2.06/kWh.

A major problem in India is grid reliability. Apparently the grid supply fails regularly and while some plant can operate independently, this has not proved feasible in practice. However it appears that distributed plant such as these help stabilize local grids in these areas.

**Programme for Water Mills**

In a parallel programme, the Hilly Hydro programme provided more efficient metal wheels free of charge to over 150 traditional water mills used for milling grain. However this actually had an embodied carbon dioxide cost since the metal wheels replaced hand made wooden wheels. In addition the extra efficiency could not be used since the mills had a fixed market need, with no alternative markets available, and trade was usually carried out by barter so that the new metal wheels could not be repaired – there was no cash income generated. Nevertheless the programme proved very popular and is being replicated in a number of other areas. Electricity generating watermills are becoming very popular in the remote hills of Uttaranchal and Jammu & Kashmir.
EVALUATION

Implementation varies significantly between the states and it is reported that it has been by far the most successful in Himachal Pradesh and its neighbour, Uttaranchal. Apparently Himachal Pradesh is a state that has a reputation for business honesty and trustworthiness and also the State electricity utility is reliable and sound since it already has a major resource of large hydro producing very cheap electricity.

While the project proved a success in promoting a small hydro programme, it did not promote grid independent small hydro for remote regions as proposed, and the benefits from the Mills programme are uncertain.

The preparation of such a programme demonstrates the value of a central clearing house and plan promoting such development. While a comprehensive programme may help identify problem sites from an environmental point of view and direct proposals into other areas.

However the differing commitment to the Hilly Hydro programme indicates how much such an approach depends on local enthusiasm.

One key advantage in India is that the river and water flow is owned by the state itself, so that it has effective control over the development of the resource and has a key incentive to develop the resource – in the long term it is a potential source of funding for the State.

FURTHER ACTION

The policy and planning programme has been replicated in a number of states in the Indian Himalaya and Himalayan foothills, and has also since been adopted in other states outside this region, for instance Kerala in the far South of India. These are preparing zonal plans and SHP master Plans for their states.

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Assistance provided by Himurja.
Planning for Small Hydro

North Douro (Portugal)

**GENERAL ASPECTS**

The North Douro is the heart of the Port Wine country, entered on the World Cultural Heritage list of UNESCO and with many designations to protect its natural heritage and landscape. It is a plateau with deeply incised valleys leading down to the Douro.

**BACKGROUND**

Development of small hydro in Portugal has been held back by a number of problems, including the prohibitive cost of network connections for small units, the insufficiency of the hydraulic resource in relation to the cost of investment, and the impact on the flora and fauna. The time delay in obtaining all the permissions from the relevant ministry can be very long indeed – up to 9 years to get authorisation being routine.

Portugal is however trying to stimulate small hydro production in order to contribute to meeting its Kyoto targets and a new law was passed in 2002 designed to reduce the formalities needed for plant with a power below 150kW and to promote innovation in turbine design in order to aid connection to the low voltage network. A key element in this is the reduction of costs of small hydro. An association of seven local authorities in the North Douro, centred on the town of Vila Real, set up an energy agency in 1996 using European Union funding under the SAVE programme. This agency covers an area of 1204 km2 and has a population of 112,700. The local authorities in this area were interested in its small hydro potential which it felt could be coupled with the restoration of small historic mills in the area for tourism purposes, thus providing a supplementary economic motivation for developments.

It was felt that the development of a spatial plan covering this issue could integrate all the locations with economic potential and contribute to the reduction of all the costs involved; feasibility studies, costs of maintenance and investment etc.
ACTION

The Energy Agency prepared a small hydro spatial plan in collaboration with the partner municipalities. The objective has been to identify potential sites and potential constraints. To support this, a GIS based sieve map has been prepared identifying all the principle constraints. In practice development is restricted to four main rivers flowing down to the Douro which are blessed with a year round flow – this area has a Mediterranean climate and so water flow in rivers and electricity demand do not coincide (maximum demand in summer due to air conditioning, maximum supply in winter due to peak rainfall). A sieve map was prepared for each municipality using data provided from the plans and information on the main protective designations, and information on the medium and low tension grid. (see below)

Four key licences are needed to develop a small hydro in Portugal, for hydraulic works, electrical establishment, use of water and operation.
The cost of these licences and taxes means that it is not worth considering a licence for very small sites. Basic taxes of 3,400 euros plus inspection fees of 500 euros must be paid in addition to the costs of any impact studies or work on the preparation of any permits required.

In addition other significant barriers affect small hydro in Portugal. The cost of connection to the network is high, and small projects are generally looked down on by the major decision making bodies which find large projects easier to manage from the financial and technical point of view. Finally the environmental impact of a small hydro is often considered high, like that of a large hydro, and significant mitigation measures are often required which cannot be justified economically.

The area had a number of advantages. While it has a very varied and interesting flora and fauna, including the Alvão Natural Park, it also has a number of natural barriers along the rivers, many old mills already linked to the low tension network and an electrical network already covering a good part of the area, easy access to potential hydro sites, four small rivers with all year round flow, and some sites which already have pre feasibility studies which have not been implemented. In addition, the Vale do Douro Norte region is unusual in that the rivers concerned have little or not value for fisheries, and so this factor is not a constraint.
A study of the mills in the region identified 27 former mill sites, 15 on the River Pinhão, 6 on the Rio Tinhela, and 6 on the Rio Teixeira. It was decided to prepare feasibility studies on 4 mills in the area which would act as pilot studies for others on the four main rivers concerned. These studies would ensure that the projects were viable, that external factors were fully taken into account in the decision making, and that a number of locations identified were related to the development involved and the investment costs. The four sites demonstrated the range of sites available:

<table>
<thead>
<tr>
<th>Location / River</th>
<th>State of Mill</th>
<th>Electricity network</th>
<th>Head (m)</th>
<th>Flow (m3/s)</th>
<th>Power (kW)</th>
<th>Investment costs (€)</th>
<th>Production (MWh)</th>
<th>Income (€)</th>
<th>Pay-Back (yrs) *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabril / Tinhela</td>
<td>ruined</td>
<td>Medium tension nearby</td>
<td>6,0</td>
<td>4,0</td>
<td>180</td>
<td>411,500</td>
<td>750</td>
<td>55,000</td>
<td>4.4</td>
</tr>
<tr>
<td>Mesão Frio / Teixeira</td>
<td>restored</td>
<td>Consumers and low tension nearby</td>
<td>5,3</td>
<td>1,3</td>
<td>50</td>
<td>144,000</td>
<td>200</td>
<td>17,000</td>
<td>5.1</td>
</tr>
<tr>
<td>Esteva / Pinhão</td>
<td>restored</td>
<td>Connected to low tension and medium tension nearby</td>
<td>10,5</td>
<td>2,4</td>
<td>177</td>
<td>369,500</td>
<td>610</td>
<td>45,700</td>
<td>5.3</td>
</tr>
<tr>
<td>Tourinhas / Tourinhas</td>
<td>ruined</td>
<td>Low tension nearby</td>
<td>70,0</td>
<td>0,3</td>
<td>140</td>
<td>313,000</td>
<td>540</td>
<td>48,000</td>
<td>3.9</td>
</tr>
</tbody>
</table>

*(Investment/Income includes a 40% grant to investment)

The combined proposal and pre-feasibility studies were presented in a study published in draft in February 2005 and were put out to consultation with the interested parties concerned.

**EVALUATION**

This project approached the problem of a spatial plan from a different angle than the others. It started on the principle of interesting the local authorities concerned in four pilot projects to demonstrate to them the viability of small hydro as a means of local economic regeneration and restoration of their local heritage. Using these as examples, it is intended to promote the concept of an integrated strategy for the restoration of mills as small hydro sites and tourism resources among the local authorities in the region. The sieve map process has been used for the four pilot projects and worked through in terms of appraising the proposals impact. It is now hoped that further projects will be promoted as the new spatial plan will be able to identify each new proposal in a context, thus reducing the costs of feasibility and impact studies, enabling banking finance to be more easily obtained, and easing the permit process in the permitting authorities.
It remains to be seen whether this approach is more successful, and in particular whether, as hoped, this actually reduces the burden of the delays inherent in the authorisation process by obtaining an approval for a programme of small hydro at one time. The sites are relatively large compared with other case studies, with capacities in the range 50-180kW. Payback is in the 7-10 year range, but this is significantly reduced when the available grant aid is taken into account so the financial incentive to develop is significant.

**FURTHER ACTION**

After publication of the feasibility studies it is proposed to prepare an inventory of sites and organise them into groups or classes. With this information there will be the wherewithal to identify a programme of investment and bring investors together for a larger scale development. This will involve regular meetings with key decision makers in the region in the municipalities and districts and the publicizing of the results already obtained.

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Planning for Small Hydro

**GENERAL ASPECTS**

The Mont Pilat is a Regional Natural Park based on the Pilat Ridge between Lyon and St. Etienne. The wooded massif has a number of steep, fast flowing small rivers that were powered many small mills in the last century, among these the Déôme Valley. The study area has a population of 6500 on an area of 160km².

**BACKGROUND**

The implementation of the Water Framework Directive will require an accurate evaluation of the naturalness of rivers and lakes. With this in mind the French Agency for the Environment and Energy Management is developing a specialised procedure for evaluating water courses that will be used for preparing maps of river quality and ecological status. The resulting maps are an essential aid in identifying locations where further intervention is acceptable and those where the naturalness of the river must be preserved, and this can form the basis for preparing a plan for small hydro. Therefore Ademe has funded a study designed to identify those sites best able to accommodate small hydro in a sustainable manner.

**ACTION**

A draft procedure has been developed by the consultancy ASCONIT Consultants, based in Lyon, in collaboration with Renewable Energy Department in Ademe Sophia Antipolis and other stakeholders, to produce a weighted evaluation checklist for the appraisal of the small hydro potential of rivers. This is intended to be a national framework for the assessment of rivers in advance of the implementation of the Water Framework Directive. The technique was tried out on a pilot area in the Vercors, the valley of the Bourne River, as a means of appraising the ecological status of rivers for the purposes of the Water Framework Directive. However this area had little hydroelectric potential and so another area was chosen to apply the technique for the preparation of a local plan for small hydro.

The SPLASH project, in which Ademe participates, is designed to prepare local plans which simplify the application and approval process for small hydro in Pilot areas in five European Union countries: France, Ireland, Portugal, Greece and Poland. This seemed an ideal framework to try out the system. The Parc Naturel Régional du Pilat near Lyon was interested in promoting...
the restoration of small hydro sites in its area, in part to promote the restoration of its industrial heritage for tourism purposes and in part to promote sustainable energy generation.

Climat-Energie-Environnement was appointed to apply the process to an area in the valley of the Déôme in the southern part of the Park. The study area consisted of 8 communes out of the 47 in the Community of Communes that constitutes the Parc regional. The study area covered five small headwaters of the Cance, the Déôme, the Argental, the Riotet, the Ternay and the Moulin Laure. These are swift, steep rivers with a slope of 2.6% in the case of the Déôme and 5-6% in the case of the others.

The Appraisal Framework

The appraisal system consists of a series weights that can be applied to any uniform stretch of river to assess its naturalness and suitability for small hydro. The appraisal was on the basis of two main factors: the energy potential and the ecological status.

The energy potential is assessed on the basis of two main factors:
- The creation of new sites whose practicality is measured through the appraisal of the river gradient and the water flow available
- The improvement of existing sites through improvement of existing small hydro, the use of the reserved flow, and the use of existing weirs and dams.

The ecological status is assessed by three main factors:
- The physico-chemical quality and biological quality of the water itself.
- The biological quality of the water environment including consideration of the degree of artificialisation of the bed of the water course, the interference with the transport of solids, the free circulation of the water and the disturbance affecting the water discharge.
- The heritage value via
  - The presence of specially valued species
  - The ecological value of a water catchment or a section of river
  - Including the consideration of the free circulation of fish as a factor in the classification of watercourses
  - The presence of migratory fish

The weighting values obtained from these assessments can be used to produce a grading of stretches of river which are uniform for a selection of constraints. These can be integrated to give an appraisal of their suitability for small hydro.

Factors used to assess energy potential

<table>
<thead>
<tr>
<th>Weight</th>
<th>0</th>
<th>1</th>
<th>3</th>
<th>5</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building new structures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Hydrological Resources

<table>
<thead>
<tr>
<th>Annual average flow</th>
<th>&lt;0.1</th>
<th>0.1-1.0</th>
<th>1-5</th>
<th>5-10</th>
<th>&gt;10</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Regularity of flow</th>
<th>Seasonal flow only</th>
<th>20&lt;R</th>
<th>5&lt;R&lt;20</th>
<th>2&lt;R&lt;5</th>
<th>R&lt;2</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Regular winter flows</th>
<th>W=Winter average flow/annual average</th>
<th>W&lt;1</th>
<th>1&lt;W&lt;2</th>
<th>2&lt;W&lt;3</th>
<th>3&lt;W</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Slope (m/m)</th>
<th>Section bypassed or eddy</th>
<th>S&lt;1 in 1000</th>
<th>S between 1 in 1000 and 1 in 100</th>
<th>S between 1 in 100 and 1 in 10</th>
<th>S over 1 in 10</th>
</tr>
</thead>
</table>

- Improving existing sites

<table>
<thead>
<tr>
<th>Improving SHP plant</th>
<th>Percentage of potential already used</th>
<th>90%</th>
<th>80%</th>
<th>70%</th>
<th>60%</th>
<th>50%</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Possibility of overdesign</th>
<th>150%</th>
<th>125%</th>
<th>100%</th>
<th>75%</th>
<th>50%</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Generation possible from the reserved flow (kW, using formula: P=9.81*Q_{res}^{0.9} H_b)</th>
<th>P&lt;50</th>
<th>50 to 100</th>
<th>100 to 200</th>
<th>200 to 400</th>
<th>&gt;400</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Height of existing weirs and dams (m)</th>
<th>&lt;2m</th>
<th>2-2.5m</th>
<th>2.5-5m</th>
<th>5-10m</th>
<th>&gt;10m</th>
</tr>
</thead>
</table>
Factors used to assess Ecological status

<table>
<thead>
<tr>
<th>Weight</th>
<th>0</th>
<th>1</th>
<th>3</th>
<th>5</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factor</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physico-chemical quality of water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall physico chemical quality assessed by SEQ of water checklist</td>
<td>Bad (Red)</td>
<td>Mediocre (Orange)</td>
<td>Average (Yellow)</td>
<td>Good (Green)</td>
<td>Very Good (Blue)</td>
</tr>
<tr>
<td>Hydrobiology</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uses different biological indices based on macro-invertebrates prepared in collaboration with the IBGN</td>
<td>Bad (Red)</td>
<td>Mediocre (Orange)</td>
<td>Average (Yellow)</td>
<td>Good (Green)</td>
<td>Very Good (Blue)</td>
</tr>
<tr>
<td><strong>Hydromorphology</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creation of artificial river bed</td>
<td>Very Significant</td>
<td>Significant</td>
<td>Average</td>
<td>Limited</td>
<td>Absent</td>
</tr>
<tr>
<td>Transport of solids</td>
<td>Very strong V&lt; 1M m³</td>
<td>Strong</td>
<td>Average &lt;100,000m³</td>
<td>Limited &lt;10,000 m³</td>
<td>Absent</td>
</tr>
<tr>
<td>Free movement of fish</td>
<td>Isolated sector isolated without tributary</td>
<td>Isolated sector with tributary</td>
<td>Non-isolated sector But movement difficult</td>
<td>Sector with free movement</td>
<td></td>
</tr>
<tr>
<td>Modification of river flow regime</td>
<td>Very significant</td>
<td>Significant</td>
<td>Limited</td>
<td>Minimal</td>
<td>None</td>
</tr>
<tr>
<td>Abstraction – Water remaining in river as percentage of annual average flow</td>
<td>&gt;50%</td>
<td>&gt;75%</td>
<td>&gt;85%</td>
<td>&gt;95%</td>
<td>No abstraction</td>
</tr>
</tbody>
</table>

**Biological Heritage**

Noteworthy and protected species. | None | Unlikely to be present | Species protected on national scale | Species in Annexe II of Habitats Directive | Species in Annexe IV of Habitats Directive |

Evaluation of the ecological interest of a catchment or stretch of river | No considerations | PNR | National Park, ZNIEFF II | Voluntary Nature Reserve, ZNIEFF I | Arrete de Biotope, NATURA 2000 |

Fishery potential | No data | Poor | Moderate | Good | Excellent |

The 8 communes in the area had already prepared a Contrat de Riviere for the River Cance, its tributary the Déôme, and the tributaries of the latter as a result of a severe flooding episode in 1996. This was published in 2002. The river basin covers 410 km² and falls across the boundary between two Departements. The tributaries arise on the Pilat Ridge at an altitude between 1,080 and 1,430 metres. The rivers are steep sloping and lie in deep V-shaped valleys in the upper reaches, (slopes from over 5% in the tributaries of the upper Déôme, 4% in the Upper Déôme itself to 1.5% in the section near the Cance). A further V-shaped section lies lower down the river profile as the river passes between erosion surfaces. Since the rocks are impermeable, there is no water table and the river flow is directly dependent on the rainfall and there are very low water levels in summer. The rainfall varies between 1,300 mm on the summits and 775 mm at lower altitudes. There are a number of flow gauges from which the QMNA5 (low water flow recurring only once every 5 years) can be estimated.
After an analysis of the existing sites available, site visits were made in November 2004 to 2 sites in the area which are already operating and 6 which were identified as potential developments.

Meetings held with the Parc Naturel Régional and the Communauté des Communes had already indicated a keen interest to restore local mills for small hydro, in particular to promote new tourism features in the area and encourage the restoration of the built heritage. Information was obtained on about 50 mill sites that had been operating at the start of the 20th Century which formed the basis of the evaluation of future potential. Indeed, it was felt by both Ademe and the PNR that, in the context of this study, the appraisal should be made by applying the index to specific mill sites rather than stretches of river per se and this was the approach adopted. Indexes were obtained for the energy potential and the environmental impact. Additional advice was obtained from the owner of one of the small hydro plant operating in the area on the energy potential, and in particular the head, of the different sites. He made a number of suggestions including the grouping of ten sites in close proximity on the River Ternay.
Most of the data input needed to prepare maps of the different influences on the river had been received by the time meetings were held with the Syndicat de Rivière in April 2005 to discuss their views on potential developments. However particular difficulty was found in getting accurate figures regarding the head at existing sites. In addition liaison was maintained with the Energy Information Centre of the Département of the Loire which had carried out feasibility studies on a number of sites.

The final plan prepared by Climat-Energie-Environnement was published in July 2005. This recommended priority be given to 21 sites, with a combined potential generation of 1.1MW. Of these one site was on the Argental, 6 on the Deome, 4 on the Riotet and there was a combined project for 10 sites on the Ternay.

**EVALUATION**

The careful development of an evaluation checklist used weights developed in consultation with experts in the field. Applying this technique requires the political involvement of politicians and this depends on a desire to resolve the conflicts concerned. This does not always have priority, not only in France, but also in other European countries. Interest tends to be aroused when it is believed that restoration of hydro sites will also bring associated benefits related to tourism.

In practice the methodology developed by ASCONIT is an interesting approach which merits wider adoption in other European countries. It is being developed for wider reasons than small hydro, being a useful tool for river basin planning in the context of the Water Framework Directive. The method starts from the principle that assessment is linear, but in practice both the area based approaches of Cork and the pixel approach of Greece also finally end up with a map of a net of rivers assessed for suitability. However the selection of uniform stretches of river presents significant problems in practice.

The Asconit methodology requires complex data, sometimes not available at all, or not available in a GIS format, particularly on small rivers. Climat-Energie-Environnement has included some adjustments to take account of this. In itself, however, it is not a local plan, only a support to the development of a local plan. The
appraisal has to be supported with other factors such as the existence of water use rights attached to the land, proximity to inhabited dwellings, accessibility to the grid network, access to the site and other potential benefits. The final plan involved detailed site investigation incorporating the results of the methodology.

Naturally in the first application of this technique for small hydro purposes, some weaknesses were found in the approach. For example when preparing the energy potential index, the element for slope is a useful factor when assessing the potential for new structures, but assumed too great a weight in this study where existing structures are being evaluated. It was suggested that more weight should be given in this case to the flow and the head on the existing structure.

**FURTHER ACTION**

The motivation for the Pilat plan is primarily linked to tourism, preserving industrial heritage and the area’s image as a clean natural area. The contribution to fighting climate change is evidently a positive attribute, but like in most areas, the main driving factors are local and economic. The plan prepared is an excellent model for this type of project. The publication of the plan should give a boost to the realisation of those objectives and has drawn attention to the potential that exists. It remains to be seen whether, as a result of this support, the 23 sites identified are rapidly developed.

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Planning for Small Hydro

Prądnik Valley
Sułoszowa (Poland)

**GENERAL ASPECTS**

The Prądnik Valley lies 15 km North of Kraków, capital of Poland in ancient times. It is a small steep sided and very beautiful limestone valley which mainly lies in the Ojcowski National Park.

**BACKGROUND**

Local small hydro developers in Poland come up against many brick walls. One enterprise in Nowy Sącz prepared 10 small hydro projects that were in principle viable but two years later had found that 8 of them were stuck in bureaucratic obstacles. Others find it difficult to get information on potential sites from the Water Management Agency. Still others have opposition from the local Mayor. All in all they have a tough time. Therefore the idea came forward that perhaps, if a local plan could be produced, those sites appropriate for development could be identified, thus permitting the developer to concentrate on those sites which fit into an overall planning strategy. The Małopolska Agency for Energy and Environment agreed to prepare such a plan and proposed the SPLASH project under the ALTENER programme to implement it.

**ACTION**

The initial stage involved identifying an area to prepare a plan. A consultative “blue committee” was formed with representatives of the regional and local authorities, the water agency, the regional electrical utility and other interest groups. Initially it had been planned to prepare a plan for the Raba and Sreniawa Valleys, but getting support from the Water Agency proved difficult. At a local level good cooperation was obtained, but the local office did not have the authority to confirm the practicality of development at particular sites. While information on a list of barriers in the river course exists, no further cooperation was obtained from the Agency who was unwilling to suggest any potential sites – saying there are no potential sites on the watercourse. Thus at regional level similar barriers were placed in the way of implementation to those found at the individual site level.

A questionnaire was sent around to all the 220 local authorities in the Małopolska Region asking them if they have information on potential small hydro sites and whether there are any sites identified on the existing land use planning documents. In total 42 local authorities replied. A number of potential sites were identified which in principle had local authority support. However most authorities that replied had only one particular site in mind.
One local authority that showed strong interest was the local authority of Sułoszowa. This authority was located on a small stream that had driven a large number of mills during the 19th century. It was hoped to reinstate these mills to produce power although there was a certain naïve optimism about the amount of power that one could expect to generate. A meeting was held with the local authority and the National Park and both expressed interest in reinstating the mills which formed a cultural feature of the Park. A local developer had links with a German manufacturer who constructed mill wheels of modern design and materials so that the original form of mill wheel could be used to generate electricity and this type of approach was thought to be appropriate.

In the light of this response a meeting was held with the local residents in both this local authority and in areas lower down the valley and the national park staff. The possibility of establishing a co-operative programme to reinstate the mills was raised. Many owners expressed interest in restoring their mills and it was decided to prepare a pre-feasibility study of the mills in the valley to investigate their suitability for reinstating hydro generation. It was decided to investigate the question of establishing a cooperative association.

A local expert was appointed to carry out a study, of which a draft version was prepared in December 2004, which demonstrated that the owners were interested in restoring the mills at 15 mills and mill sites and that these showed potential for the installation of generation equipment. However the initial appraisal demonstrated a capacity of only 44kW. When this was examined in detail, it appeared that a simple

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### Table 1: Appraisal of the Mills on the Prądnik

<table>
<thead>
<tr>
<th>Mill</th>
<th>Head (m)</th>
<th>Catchment (km²)</th>
<th>Power (KW)</th>
<th>Est Prodn (MWh)</th>
<th>Value of electricity (1,000zl)</th>
<th>Estimated cost (1,000zl)</th>
<th>Payback (Yrs)</th>
</tr>
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<tbody>
<tr>
<td>Giebultowski</td>
<td>2.5</td>
<td>104.5</td>
<td>10.83</td>
<td>64.47</td>
<td>10.6</td>
<td>125</td>
<td>12</td>
</tr>
<tr>
<td>Pachłański</td>
<td>2</td>
<td>102</td>
<td>8.45</td>
<td>50.24</td>
<td>8.3</td>
<td>94</td>
<td>11</td>
</tr>
<tr>
<td>Nowacki</td>
<td>2.5</td>
<td>102</td>
<td>10.56</td>
<td>62.8</td>
<td>10.4</td>
<td>107.5</td>
<td>10</td>
</tr>
<tr>
<td>Cieslik</td>
<td>2.5</td>
<td>102</td>
<td>10.56</td>
<td>62.8</td>
<td>10.4</td>
<td>97.5</td>
<td>9</td>
</tr>
<tr>
<td>Jabłonski</td>
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<td>73.5</td>
<td>3.86</td>
<td>22.73</td>
<td>3.7</td>
<td>100</td>
<td>27</td>
</tr>
<tr>
<td>Tarnowka Grodzisko</td>
<td>2.5</td>
<td>48</td>
<td>4.63</td>
<td>26.62</td>
<td>4.4</td>
<td>74</td>
<td>17</td>
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<tr>
<td>Bosak</td>
<td>4.5</td>
<td>52</td>
<td>9.12</td>
<td>52.74</td>
<td>8.7</td>
<td>105</td>
<td>12</td>
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<tr>
<td>Mosur</td>
<td>3.5</td>
<td>51</td>
<td>6.94</td>
<td>40.08</td>
<td>6.6</td>
<td>77</td>
<td>12</td>
</tr>
<tr>
<td>Katarzynski 1</td>
<td>3.3</td>
<td>45</td>
<td>5.67</td>
<td>32.48</td>
<td>5.4</td>
<td>74</td>
<td>14</td>
</tr>
<tr>
<td>Katarzynski 2</td>
<td>3.3</td>
<td>45</td>
<td>5.67</td>
<td>32.48</td>
<td>5.4</td>
<td>74</td>
<td>14</td>
</tr>
<tr>
<td>Piotr Tarnowka</td>
<td>1.5</td>
<td>51</td>
<td>2.58</td>
<td>14.89</td>
<td>2.4</td>
<td>100</td>
<td>41</td>
</tr>
<tr>
<td>Waclaw Wilk</td>
<td>2</td>
<td>45</td>
<td>3.44</td>
<td>19.69</td>
<td>3.2</td>
<td>78</td>
<td>24</td>
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<tr>
<td>Wład Krzemien</td>
<td>3</td>
<td>42</td>
<td>4.76</td>
<td>27.12</td>
<td>4.5</td>
<td>115</td>
<td>26</td>
</tr>
<tr>
<td>Wug Krzemien</td>
<td>3.5</td>
<td>42</td>
<td>5.56</td>
<td>31.64</td>
<td>5.2</td>
<td>100</td>
<td>19</td>
</tr>
<tr>
<td>Zbi Krzemien</td>
<td>5</td>
<td>42</td>
<td>7.94</td>
<td>45.20</td>
<td>7.4</td>
<td>80</td>
<td>11</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td><strong>100.5</strong></td>
<td><strong>585</strong></td>
<td><strong>96.6</strong></td>
<td><strong>1401</strong></td>
<td><strong>14</strong></td>
</tr>
</tbody>
</table>

A generation capacity of 66.6% of annual mean flow was assumed in this ground water fed stream. Mills in italics are outside the National Park Boundary.
estimation based on a single flow rate whatever the location and an averaged head had been used and the income was estimated on the basis of the retail price of electricity inclusive of distribution charges independent of whether the mill owner had a use for the electricity generated. However, even recalculating on the basis of the purchase price of the current without distribution charges, there would be long payback periods. So MAES reassessed the sites on a different basis using the estimates of actual head and estimated catchment areas to calculate the power generated at each single mill. Head and flow is small and with individual sites capable of generating from 2 to 8 kW. This gave a very broad estimate of the total potential of all the sites at about 68 kW. Some of these sites had very long payback periods (40-60 years), while others were 32 years or less. This comes within the bounds of what might interest a private operator should they obtain grant aid as part of a European Union package. There is very limited potential for grant aid for small hydro in Poland from National sources.

**Evaluation**

The interest of these participants was strongly linked to a desire to restore the mill buildings for tourism purposes. The National Park is a popular tourist destination lying only 15 km from Kraków, Poland’s prime tourist destination. This represents an approach strongly linked to cultural heritage criteria and in fact the restoration of the use of the buildings for water power is seen as the continuation of a historically significant use in the area, a use that could improve the tourism potential of the area.

In practice the sites need to be reassessed from the point of view of the objective of installation. It may be that a different approach is needed according to location. Some of the sites do not lie in the national park. Others lie within sensitive areas. It may be that for some of the more marginal locations the installation of a cheaper turbine might be appropriate, while in others the tourism opportunity means that the installation of water power is primarily a means to promote the historical legacy as a tourism resource.

The estimates are based on an annual average flow measured at one site. This is consistent with another estimate given for one year at one site. However to proceed further a number of actions need to be undertaken:

- Improved feasibility studies on individual sites based on true costings for the equipment needed and actual monthly mean flow measurements.
- Appraisal in detail of the potential for improving the tourism marketability.
- Investigation of the potential for common submission to grant aiding sources – e.g. the Structural Funds.
- Establishment of a cooperative of willing owners on the Somerset model.
- Cooperation with the local municipalities and National Park Authority to define the acceptability of and constraints on the proposed works (Overall approval of the concept had already been obtained from the Park and main local authority).

The SPLASH funding did not permit continuation within the timescale of the project, but additional funding was found and it is now to be continued along these lines using further funding via the InterregIIIIC programme.
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Assistance provided by Małopolska Agency for Energy and Environment.
Photo Credits: M. Pochwat.
Planning for Small Hydro

South Somerset (UK)

**GENERAL ASPECTS**

South Somerset (pop. 154,000) is a large rural local authority in South West England. The area has areas of low lying pastures, part of the "Somerset Levels" and ridges of limestone hills. Small market towns such as Yeovil are a feature of the area.

**BACKGROUND**

South Somerset District Council supported a local Agenda 21 process and identified key issues in their area. Energy came out as a vitally important factor and the Local Agenda 21 Officer, looked for methods of promoting renewable energy sources in their area within the framework of a limited budget in terms of resources and time. One potential source was the legacy of old mills in the county which are now mainly used as dwellings. Few such mills have been restored to make use of their potential for generating electricity and when asked, mill owners all said that they had thought of generating electricity but all had been put off by the complicated bureaucratic procedures involved in installing plant. In lowland areas like South Somerset with small river flows, such mills generally have low power capacity and the bureaucratic process means that it is difficult to overcome the transaction costs of installing equipment. The local authority suggested to them that joint action could help overcome these hurdles.

**ACTION**

The local authority approached 19 mill owners in total and fourteen were suitable for generating hydroelectricity. On Council encouragement they formed a mill owners group, Wessex Water Power Group and this set about preparing a combined proposal for support. The group was intended to seek joint support for funding, jointly negotiate with the main regulatory body, the environment agency and jointly negotiate about sales of surplus electricity.

A small grant of € 8,000 from the Energy Saving Trust coupled with a € 160 contribution by each mill owner enabled the project to be launched.

RHPL was contracted to carry out an assessment of each site. An appraisal at each site visit to estimated the head and flow, the needs of the owner and the general condition of the civil engineering structures. Computer-generated projections of flow were compared against historical data from river gauges and were determined to be consistent. Energy efficiency measures were also identified at each site that could maximise any income generated through sales of electricity. A flow duration curve was generated and projections were made for outputs from various types of turbine. The results were used to discuss the various options available to the owners for redevelopment and to provide estimates of the annual energy yield.
Following this project RHPL set up a subsidiary, Hydro-Generation, to carry out this type of work.

The various interested parties were involved in promoting the project. Each mill presented different problems, and had to be taken individually through the approval process. This varied according to the site. Some buildings were historic buildings and special approval was needed. In most cases a turbine could be installed without affecting the historic features of the building. An abstraction licence was needed from the Environment Agency and in most, but not all sites, planning permission was needed.

In total 11 mills were finally identified for taking further with a potential capacity of about 155kW. The individual plants had a capacity varying from 5kW to 40kW. However during the slow process of further investigation, one site finally proved too impractical from a financial and environmental point of view.

A bid was made to the Energy Saving Trust’s support fund for renewable energy and a €125000 grant was obtained for the necessary investment. Further funding of €63,000 was obtained from SWEB’s Green Electron Fund financed by the extra tariff paid by consumers buying renewable electricity. The remainder, estimated at 60% of total costs overall, is provided by the owners. In general simple fixed propeller turbines are proposed which are cheap and simple to operate.

Originally it was thought that the electricity would be mainly used in the mills concerned for their own use with surplus being sold off. In practice it has proved more profitable to sell the electricity to the grid for 7.2p and receive the favourable price for renewable electricity which takes account of its contribution in meeting the companies’ renewable energy obligation (failure to meet the obligation costs the companies 3p per kWh). Mill owners will then buy in electricity from the grid at a lower price of 6.5p. The payback period is of the order of 3-9 years with grant assistance.

**EVALUATION**

This project has successfully promoted the development of micro hydro sites that would not otherwise be developed. However the process is slow and time consuming and preparing the necessary documentation for these sites, which are relatively straightforward and non-controversial, remains expensive compared to the expected yield. By January 2003 only one mill, Gants Mill (see photo below), was already in operation. Other mills including Nimmer Mill, Thorney Mill, Clapton Mill, Hinton Mill and Hornsbury Mill were still in various stages of the approval process.

However such an initiative would not have been viable without grant aid, both the initial launch grant to get the mill owners group going and the support for generation to bring the time for repayment of the capital investment down to a practical length. All these were mills occupied as dwellings and so they can be expected to derive a certain permanence. However if people only envisage living in the property for say 5-10 years, then the viability of a project with a payback over ten years is placed in question and this did prove to be an issue. The likely future income from sales is also a key issue if a major capital investment (for the mill owners concerned) is to be made. The current high price cannot be guaranteed into the future.

The benefits of combining the application procedure have appeared somewhat illusory in that each mill has had been treated as an individual proposal to the authorities. However a certain expertise has developed
that is certainly of benefit. In addition the general negotiations are simplified when a group of proposals are made, and it is clear that the mutual support from this mill owners group has been vital in getting the projects off the ground and in developing a clear set of responses from the regulatory authorities so that consistent approaches can be developed.

**FURTHER ACTION**

Such a proposal develops resources that would otherwise never be mobilised, and which, although perhaps only a short to medium term investment for their current owners, should be operating effectively 100 years or more from now and represents a basic aspiration for members of the public. It is a project worthy of much wider replication.

The South Somerset project has kindled the interest of other local groups of mill owners and a similar group has now been set up in the adjoining Mendip District Council with a €12,600 grant from the Energy Saving Trust. A further association of mill owners has been set up in Dorset. Some of the sites in Dorset are owned by a disinterested landowner or by people who are too elderly or lacking in funds to develop their mills. In these cases they are looking to find a model for development such as a trust and in the first instance some mills on the River Stour are being examined with a view to developing them on this basis. At one time there were 40,000 watermills in the UK and so the potential, even if only a small proportion of these are reused, is very significant. By way of example and by using a simple extrapolation, were 10% of this figure to be reused and were they to be equipped at an average capacity of 15kW (comparable with the Wessex Water Power group), this should provide in total new capacity of around 60MW. However the fact that launch grants are no longer available from the Energy Saving Trust will act as a brake on further such expansion in the UK.

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Assistance provided by South Somerset District Council.
Photo Credits: South Somerset District Council.
Planning for Small Hydro

Tintern, Monmouthshire (UK)

General Aspects
Monmouthshire, Wales, is a large rural municipality on the border with England. The Angiddy Valley is a tributary of the River Wye, which runs through a narrow gorge known for its beauty.

Background
The Severn and Wye Energy Agency, based in Forest of Dean District, has been working to promote renewables in their area which includes the Wye Valley. The Wye Valley is protected as an Area of Outstanding Natural Beauty. Promotion of renewables in this area will need a very sensitive approach to be compatible with the area's wildlife, landscape character and heritage interests.

In 2001 the Sustainable Development Fund (SDF) became available from the Welsh Assembly; this funding could be accessed by AONB offices for the development of special projects in their area.

The Wye Valley AONB office decided to set up a project in the southern area which they manage. This area straddles the border between England and Wales.

The Wye is England and Wales' most natural river, protected throughout its length as a Site of Special Scientific Interest and a Special Area of Conservation for its special nature conservation interest, and the lower Wye Valley runs through a particularly attractive gorge.

The project, Wye Local Power, seeks to promote the development of locally based renewable resources and has developed, for instance, a programme promoting a do-it-yourself solar power project. In view of the topography of the area there also appeared to be potential for promoting small hydro.
**ACTION**

The Wye Valley Local Power scheme is designed to promote community involvement in renewable energy. The project is managed by collaboration between the AONB who have a community initiatives officer and the Severn Wye Energy Agency based in Forest of Dean which provides the renewables expertise.

Initially the Wye Valley AONB commissioned SWEA to carry out a Renewable Energy Scoping Study for the Wye Valley; the findings of this report were presented at a community consultation meeting held in the village of Tintern in April 2002. At the community consultation local residents suggested that a small tributary valley of the Wye, the Angiddy, could rediscover its role as an energy source in former days – there were a number of industrial sites in the valley including a former charcoal ironworks.

The community consultation meeting identified several potential sites and these were refined to a short list of 6 sites which seemed possible. These were then reviewed and the various constraints identified. As a result of this analysis four sites seemed worthy of further examination, three of which were on former industrial structures and one on a small waterfall. The four landowners involved expressed support for the project and willingness to get involved.

Wye Local Power endeavoured to keep interested parties up-dated on the projects development including the local community council, the local authority covering the Tintern area and a group of interested local residents.

To further investigate the hydro sites, Wye Local Power applied for and obtained two grants to pay for a feasibility study. A grant of € 3,300 came from the Enfys programme which supports voluntary action by community groups in Wales, and the second grant of €10,000 came from the UK Government’s Clear Skies programme.

<table>
<thead>
<tr>
<th>No</th>
<th>Name of site</th>
<th>Turbine type</th>
<th>Annual energy capture prediction (kWh)</th>
<th>Simple payback (excl. maintenance) assuming 50% grant</th>
<th>Viability (5 stars = highly viable)</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ravensnest Fishery</td>
<td>Crossflow</td>
<td>15,947</td>
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<tr>
<td></td>
<td></td>
<td>200mm dia. polymer turbine</td>
<td>7,010</td>
<td>22 years 11 mths</td>
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<td></td>
<td>200mm dia. polymer turbine</td>
<td>8,449</td>
<td>19 years</td>
<td>★★★★★</td>
</tr>
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</table>

Table 1 Summary of energy output and viability

The feasibility study was professionally prepared by Renewable Heat and Power Ltd. A number of spot flow measurements were obtained from the Environment Agency in Angiddy Brook, and further measurements were taken directly during the on-site survey. Hydrafow modelling software was used to estimate flow variation throughout the year. The consultants compared a traditional solution to construct a crossflow turbine with a solution using a new design of polymer turbine designed by HydroGeneration Ltd., a Devon
based consultancy. Such small sites inevitably produce long paybacks in the range 10-30 years. The design also configured to minimize impact and construction requirements. However, assuming a 50% grant and commitment on behalf of the local community for whom the concept of renewable energy was worth more than the maximum return on money, installing turbines seemed to be viable on these sites providing a crossflow design was used. Such a design would also produce the maximum energy capture, each site producing around 20MWh per year. In total it would supply the electricity required by about 18 average British homes and avoid 36 tonnes of CO2 per annum.

One advantage of these sites is that they use existing structures on the river bed which means that the civil works are at a minimum. However this also poses problems since they are historic structures. Indeed the Angiddy Ironworks is protected by scheduling as an ancient monument.

On receiving the feasibility study a local “Focus” group was set up and a consultation procedure set up with the interested parties and local community council. An application has been made for abstraction licences from the Water Authority, the Environment Agency. The local residents involved need now to define the business structure that they will set up to manage these sites, work out a business plan in order to raise funds, and make a formal application for planning permission. The business plan was completed in Summer 2005.

**EVALUATION**

Involving the local community in the decision-making is a long drawn out process. If in addition the profitability is marginal, this can be a constraint. However the community will often be willing to support a project that is less profitable than required for a project decided on purely business lines. This appears to be the case here, and in this it is modelled on the examples in Somerset and the Prądnik Valley in Poland.

Local authority structures have a particular role here in supporting those who are willing to promote renewable energy and even invest on marginal business terms for environmental or sentimental reasons, but do not have the expertise or human resources to undertake this on their own.

Furthermore if a project is seen to have the community behind it, it helps the political process of obtaining permissions. So a long preparation time may be counteracted by a quicker run through the permit awarding process.
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Assistance provided by Severn and Wye Energy Agency.
Photo Credit: Wye Valley AONB.
TEN LESSONS TO REMEMBER WHEN PLANNING FOR SMALL HYDRO

1) Find a key partner who is actively involved in the small hydro approval or planning process to act as a leader
   This could be a local authority, the préfet, the local water agency, a national park or regional park, etc. The important thing is that there is a leader who will keep the process going through the administrative treacle that will always threaten to overwhelm it, and won’t take no for an answer.

2) Get key local stakeholders involved
   You are going to need to get all the support you can get from those representing the different interests affected by small hydro. You need therefore to involve them in the appraisal of sites, in promoting sustainable projects and in selling the message.

3) Involve potential developers
   This is the key phase when working on old mills – the owners are your most important supporters. Small hydro is very site specific and the best information comes from people who own sites or who would like to develop them.

4) Work on a rational unit to prepare a local plan
   Too small and you have no real choice. Too large and you lose the detail that is necessary when appraising small hydro sites. It all depends on who controls development and the precise objectives of the plan. It is usually desirable to work on river catchment boundaries, however small, rather than political ones.

5) Get information from universally accepted expertise
   It is important to involve respected and independent experts in evaluating resources – for instance archaeological heritage, water quality. The acceptability of your plan will depend on it.

6) Integrate your plan into the statutory planning documents if at all possible
   The plan will have that much greater weight if it is part of the statutory process and this will force the different government and local government bodies to take account of it. There are various possibilities, and the priority depends on the approval process in the country concerned – local development plan, regional strategic plan, climate change strategy, etc.

7) Screen out unsuitable areas, screen in suitable areas
   Sieve mapping is a traditional planning tool and one of the first stages in planning is to decide which areas are sacrosanct, and which areas are well adapted to generating power. GIS offers great opportunities for this, but depends on having good data (rubbish in, rubbish out). Put pressure on those who have data of public interest (e.g. the electricity network utility) to release essential data.

8) Allow adequate time
   Plans take time, and if the local community is to be adequately involved, a lot of time. But time, and the involvement of the local community, gives you the chance to produce a document with weight. Don’t underestimate this and allow years, not months.

9) Search for synergies
   Small hydro can have other benefits. Restoring historic mills for example allows one to maintain them as a local tourism and heritage resource. Using river bed structures to produce energy means that there may be someone with an interest in maintaining them – important for river regulation. Search these out and promote them since these may be stronger arguments for your project than the energy produced.

10) Go public
    There will always be interests that don’t want to participate, or simply say “No!” out of fear, “Let’s ignore this proposal and it will go away”. The planning process must be a public process. You are trying to make people participate and peer pressure helps here. Once you involve them in a team working towards the same end, sustainability, you should find that solutions are found to conflicts of interest, and they are less frightened of the problems.
This document was prepared by Energie-Cités within the scope of the SPLASH project with the support of the European Commission (Altener programme) and the French Environment and Energy Management Agency (ADEME).

The IED company contributed to this document as coordinator of the Splash project, as well as the national Splash partners who provided feedback on their respective national experiences:

- ADEME, Agence de l'Environnement et de la Maitrise de l'Energie, France
- ALPHA MENTOR, Greece
- CEE, Climat Energie Environnement, France
- CEEETA, Centro de Estudos em Economia da Energia dos Transportes e do Ambiente, Portugal
- CORK COUNTY COUNCIL, Ireland
- ESHA, European Small Hydropower Association, Belgium
- IED, Innovation Energie Développement, France
- MAES, Regional Agency for Energy & Environment Management, Poland

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