Intelligent Energy Europe

SMART –

Strategies to Promote Small Scale

Hydro Electricity Production in Europe

D4.2 Strategic Actions learned from pilot regions

WP 4 Testing of methodologies and tools in pilot regions and promoting strategic actions learned from pilot regions

15 January 2011

SMART

DISCLAIMER

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1 INTRODUCTION

To test strategies, policies and supporting methodologies & tools in different environmental, political, legislative areas of Europe, a certain number of regions were analyzed in deliverable D4.1

Informatic tools, described in deliverable D3.3, were applied in each pilot region to evaluate the possibilities to install new hydropower plants and the overall potential.

The present report will show the strategic actions learned from the SMART Project Pilot actions. The document is addressed to both potential investors and Public Administrations and is distributed among partners for dissemination in their own countries.

The report will show the collection of strategic actions learned form the applications of the informatic tools to the following Pilot regions:

- Cremona County (low land and intense agricultural exploitation region),
- Karlovac County (piedmont and hilly region),
- Trondhein County (Scandinavian region),
- Attica Region (Mediterranean coastal region),
- Thaya County (mountainous region).

Each chapter summarize the findings in the five pilot regions, with respect to common strategies and methodologies that could be used as reference also in other European countries.

2 STRATEGIC ACTIONS – ITALY – CREMONA PILOT REGION

The Cremona province occupies the central section of Padana Plain, so the whole territory is flat without any mountain or hill, crossed both by several rivers (like Serio and Adda) and artificial canals, most of them used for irrigation.

The main economic resource of Cremona Province is agriculture (mainly maize and barley, but also soya and sugar beets). Industry is quite developed, mostly in the northern zone, near Crema, where there are textiles, chemical, and mechanical factories.

The following map shows the Cremona Province:

Figure 1 – Cremona Province in the Italian context

The basin of the Cremona County chosen for testing the methodologies and tools of the SMART project, is located at the north-west side of the Cremona Province, as it is reported in the following Figure 2.

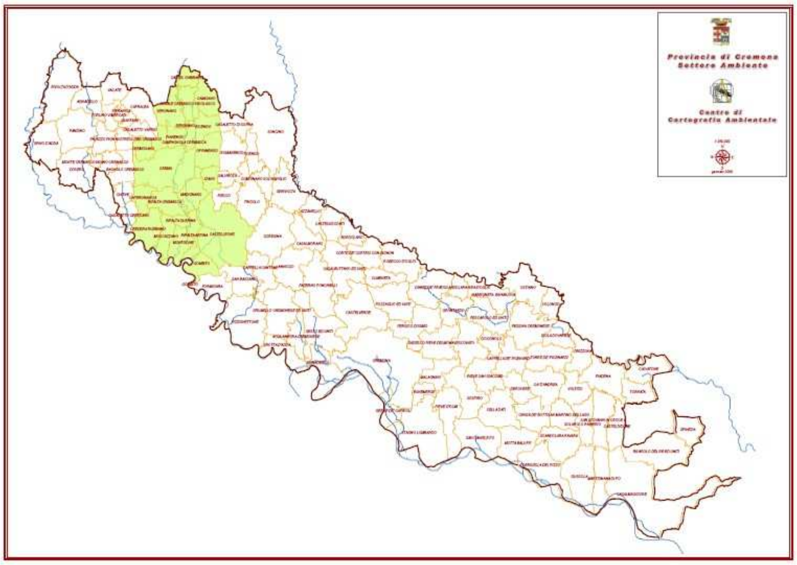

Figure 2 – Cremona Province and Pilot Area

The pilot action application in the Cremona County (Italy) regarded particularly the application of informatic tools to calculate the hydropower potential in the main natural streams on the area (Rivers Serio and Adda) and the artificial canals dedicated to the irrigation system.

Two types of software tools were applied to the region:

- VAPIDRO-ASTE, a GIS integrated numerical tool that allows the evaluation of the residual potential hydropower energy and all possible alternatives concerning the sites for hydroelectric plants along the drainage network, taking into account the relationship between the full costs of the mini-hydro power and the benefits from selling the generated power in the national market.

- SMART Mini-Idro, a tool to evaluate the main hydropower project parameters, considering the flow duration curve, the available heads and the types of turbines to be installed, the range of discharges to be used, etc. The tool calculates the cash flow of the works and it is able to identify the type of turbine to choose.

The following paragraphs will describe the acquired experience deduced from the application of the tools.

2.1 Acquired experience with the VAPIDRO-ASTE application

The application was proposed to evaluate the hydropower potential in the Cremona County area, considering concentrated plants, where the distance between the intake and the power house is small (see deliverable D3.3).

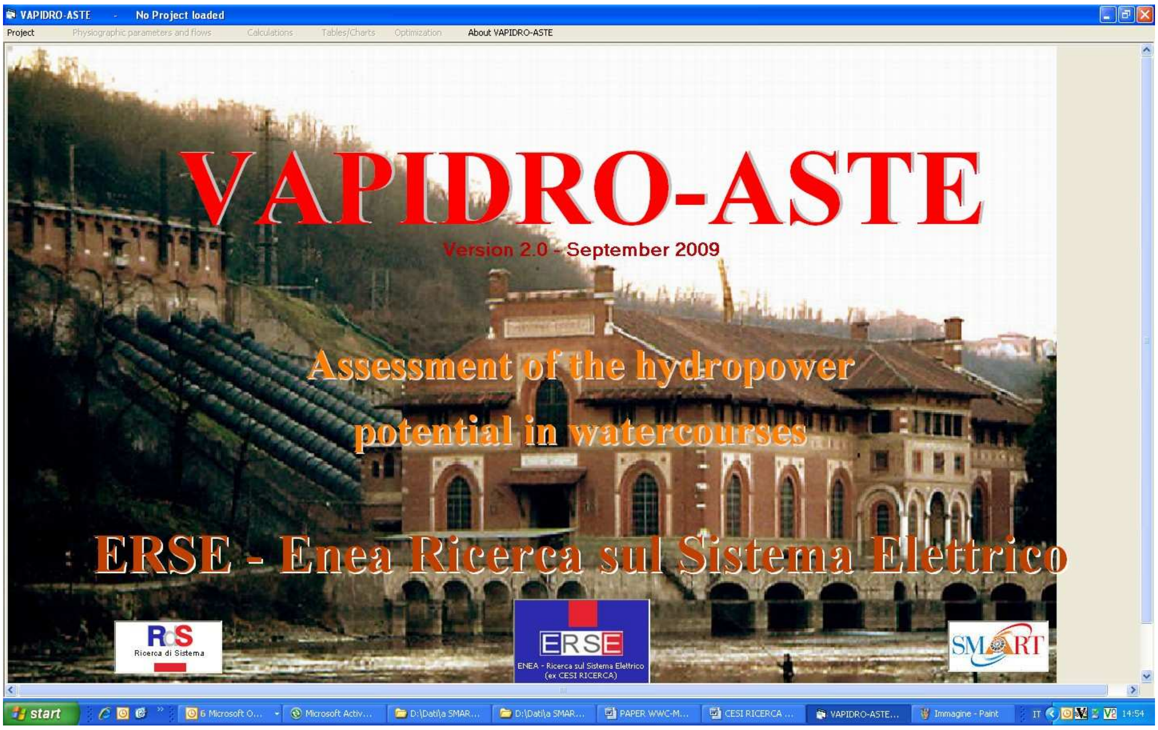

Figure 3 – VAPIDRO-ASTE start windows

The necessary data to construct the model are the following:

- the digital elevation model (DEM) of the area. In the present Italian case, VAPIDRO-ASTE is able to extract automatically the needed 90x90m DEM.

- almost one point of mean annual discharge in the selected watercourse;

- the existing points water uses.

Regarding the mean annual discharge only one point of measured value is documented in the gauge station of Ponte Cene in the Bergamo Province and one point in the Adda river, near Spino d'Adda village: the data resulted enough to define the hydraulic contour of both rivers.

The following water uses were considered to build the models:

- Irrigation, the main use in the Cremona County
- Drinking water
- Industrial uses, some withdrawals from the Serio River are dedicated
- Existing hydropower

Entering the main data into the VAPIDRO-ASTE model, hydropower potential profiles are obtained as a function of progressive and for different configurations of heads, from 0.5 to 6 m.

For example, the Figure 4 shows the map of the Energy and Power distribution, for 4 m of imposed head in the Serio river:

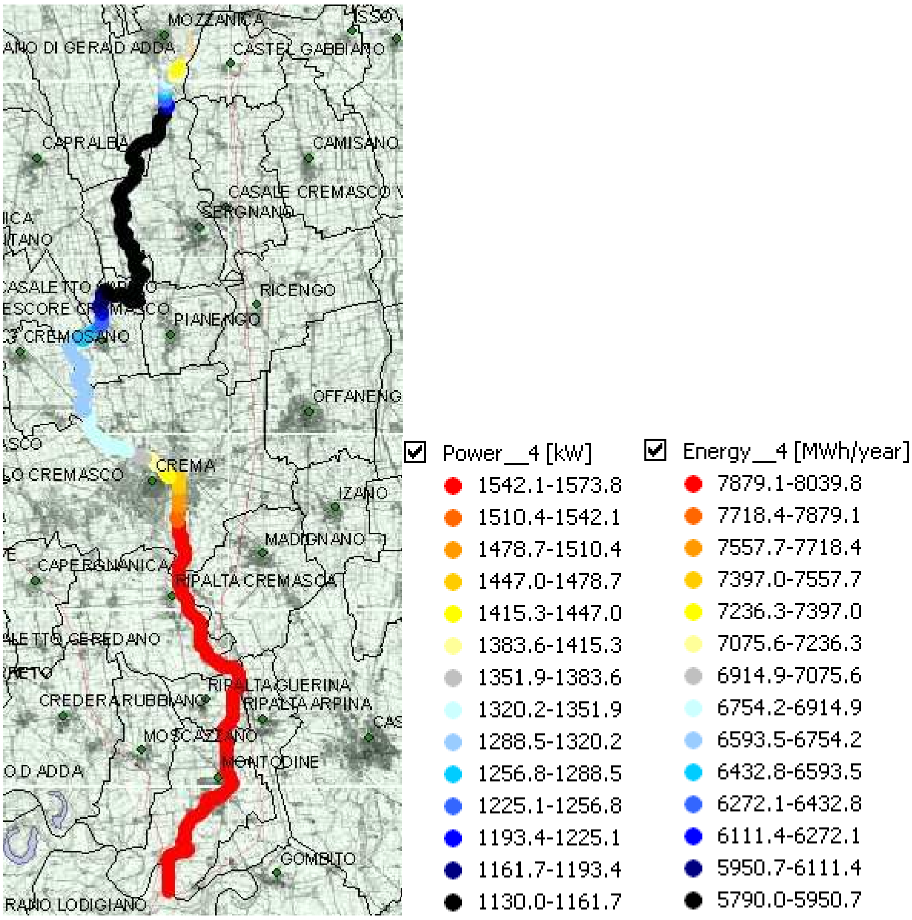

Figure 4 – Energy and power maps in the Serio river

It is possible to see that the most important hydropower potential values are developed downstream Crema city.

VAPIDRO-ASTE is capable to calculate also the financial parameters of hypothetical future mini hydro plants. For example the following figure shows the Benefit/Cost relation for a head of 4 m in the Serio River:

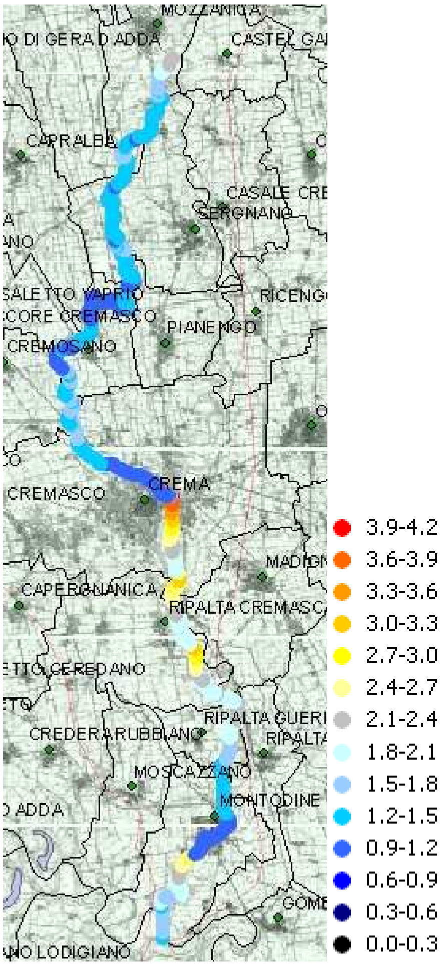

Figure 5 – Benefit/Cost map in the Serio river

The best mini hydro opportunity (orange colour) is located in the South Crema area, where it is actually reserved with a new hydropower concession.

The application of VAPIDRO-ASTE hydropower optimization module, considering the financial profiles, determined the best scheme of the global exploitation.

This procedure makes the calculation so that they are guaranteed not only the necessary DMV (minimum environmental flow) but also consider the operation of so-called multiple use, i.e. any other exploitation of existing water resources for hydropower, irrigation, civil or industrial.

The optimal pattern exploitation resulted of 5 plants in the Serio river, and 1 plant in Adda river into the Cremona pilot area.

The Figure 6 illustrates a map with the position of the potential hydropower sites. It is possible to see that 3 plants are located between the Crema city and Ripalta Cremasca, and 2 sites are located near Montodine village, approximately where the river Serio delivers the water to the Adda river.

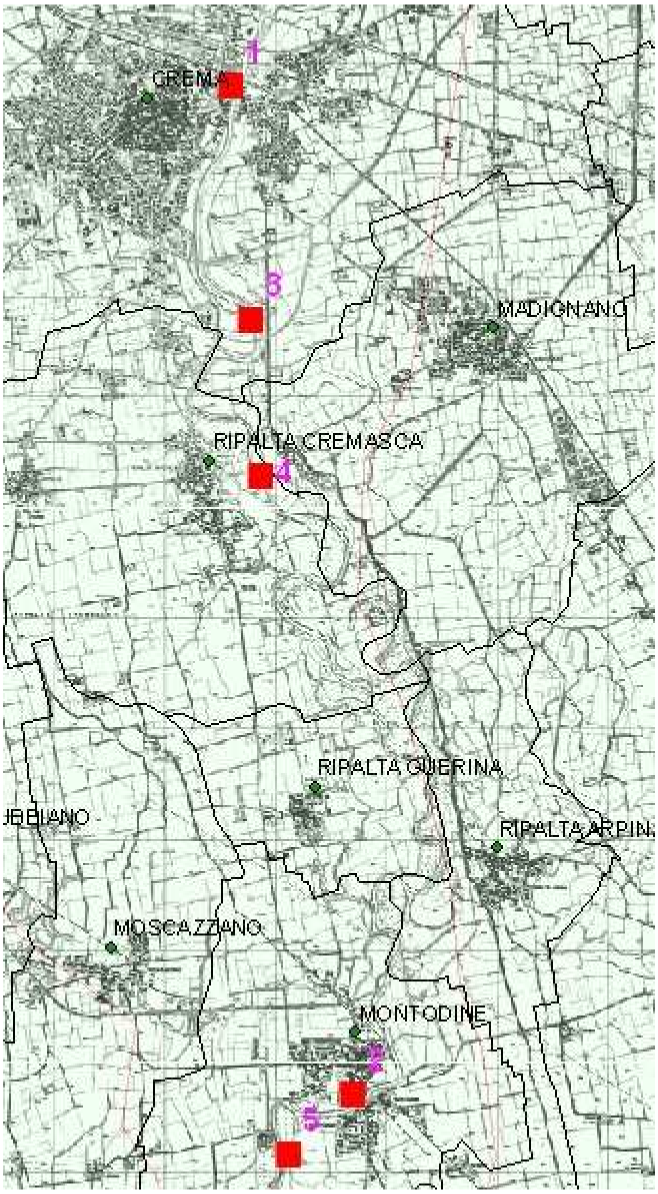

Figure 6 – Optimized hydropower potential sites calculated in the Serio river

Although the automatic definition of the river does not follow correctly the real watercourse due to the flat territory, VAPIDRO-ASTE was able to identify with success the hydropower potential points of interest.

The 5 plants are listed below in Table 1 with their characteristics. The progressive is measured from downstream to upstream, and the value listed corresponds to the cross section of each plant:

Configuration name	Barrage progr. [km]	Backwater length [m]	Turbine Flow [m³/s]	Fixed head [m]	Power [kW]	Energy [MWh/year]	Capital cost [M€]	Managem. cost [M€]	Total benefit [M€]	Benef/Costs [-]
site n.1 Crema	14.7	248	48.945	4	1460	7459	2.728	1.54	16.775	3.93
site n.2 Montodine	3.9	140	52.725	2.5	983	5022	1.962	1.095	11.294	3.694
site n.3 Marchessa	12.45	354	51.84	3	1159	5925	2.471	1.364	13.325	3.475
site n.4 Ripalta Cremasca	10.85	127	52.185	2	778	3976	1.7	0.935	8.943	3.394
site n.5 Montodine2	3	169	52.68	2	786	4014	1.752	0.96	9.027	3.329

Table 1 – Optimized exploitation on the Serio river.

As informed by the Cremona Province Administration, sites n.1 and n.2 are occupied with existing hydropower concessions. This demonstrates that VAPIDRO-ASTE is a tool that cleverly is able to identify the future potential sites with precision when they come from potentials distributed.

Figure 7 – Power plant under construction on site n.2

2.2 Acquired experience with the SMART Mini-Idro application

SMART Mini-Idro is a tool to evaluate the main hydropower project parameters, considering the flow duration curve, the available heads, the types of turbines to be installed and the range of discharges to be used.

The tool considers the possibility to apply government incentives to the investment as the "green certificates" and finally is able to evaluate the cash-flow of the investment.

The tool helps the user as a first approach to begin a preliminary project, leading to a first analysis of the economical and financial parameters of a new SHP.

The following figure shows the main SMART Mini-Idro starting window:

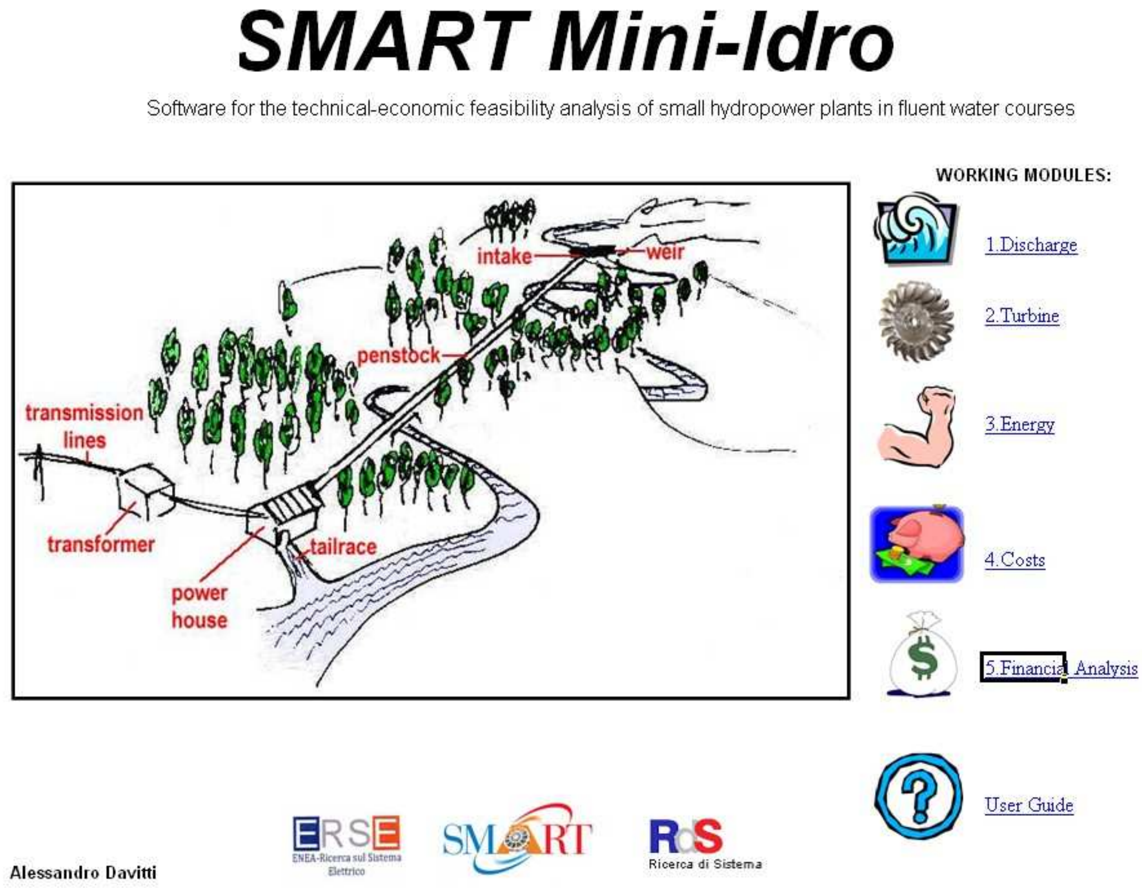

Figure 8 – Main SMART Mini-Idro window

The SMART Mini-Idro tool was applied to the sites n.3, n.4 and n.5 in the Serio river considering that sites n.1 (Crema) and n.2 (Montodine) are now a day with a concession issued and result not possible to utilize as future potential sites.

Compared with VAPIDRO-ASTE, the most important additional data needed to use the SMART Mini-Idro tool is the mean annual Flow Duration Curve in the selected river cross section.

The following table and figure show the reconstructed Flow Duration Curve at section n.3 in the Serio river:

duration (%)	discharge (l/s)
0%	120000.0
5%	81068.0
10%	66280.1
15%	59826.5
20%	52034.5
25%	48355.2
30%	45805.0
35%	41456.4
40%	38385.7
45%	35000.5
50%	32160.1
55%	29977.7
60%	27913.2
65%	26031.8
70%	23956.9
75%	21283.9
80%	20284.4
85%	17674.3
90%	16039.5
95%	14194.9
100%	6095.0
Qmean (l/s)	39229.7

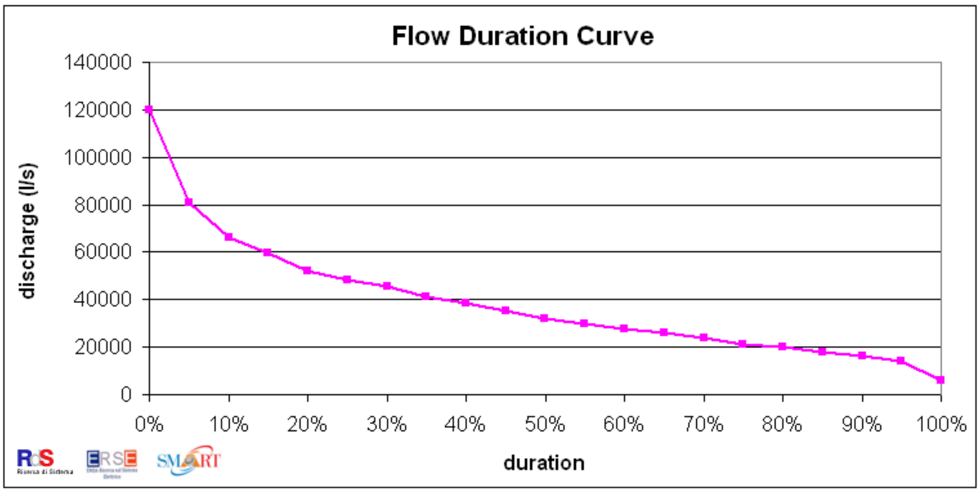

Figure 9 – Site n.3 Reconstructed flow duration curve

SMART Mini-Idro utilizes also the definition of the Minimum Environmental Flow in the river and the design discharge of the machinery.

The user input the head of the plant and eventually the penstock length to calculate the distributed and concentrated loses of the hydraulic system.

The tool is able to select the best turbine to install and the efficiency curve function of the conveyed discharge. Then the flow and power duration curves were calculated:

Energy annual production	**[MWh]**	**4 712**
Operation theoretical duration	[giorni]	256

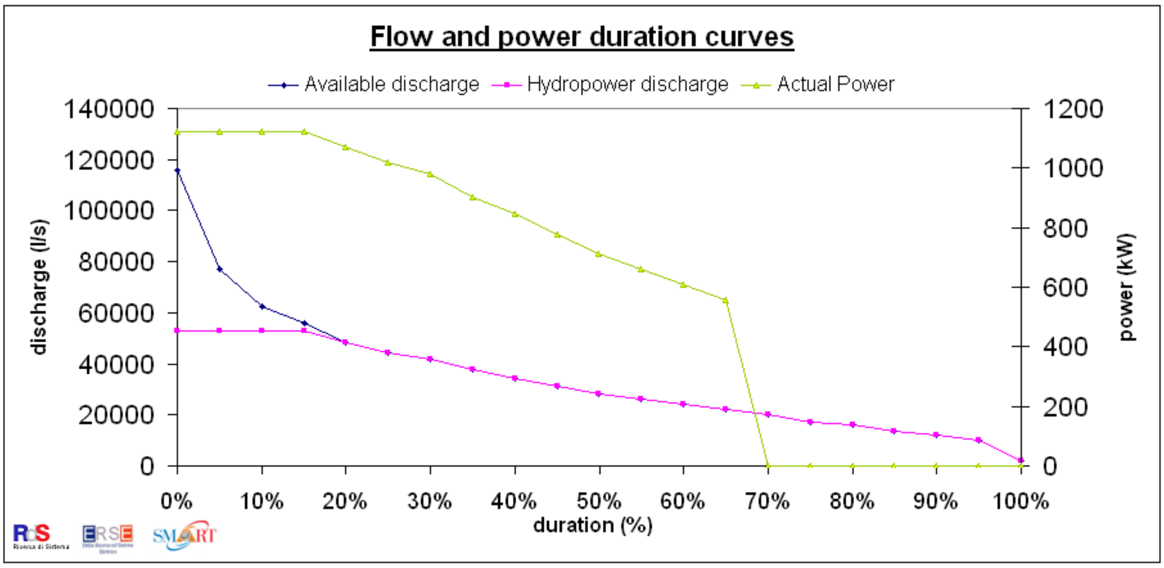

Figure 10 – Site n.3 Flow and power duration curves

Finally, using cost functions correlations, SMART Mini-Idro calculated the costs of the different components of the mini hydro plant:

- Intake costs
- Channel costs
- Penstock costs
- Powerhouse costs
- Total costs

From the point of view of the income calculation, the tool was able to calculate the energy selling and the green certificates benefits for the whole life of the plant.

The following figures represent the financial parameters deduced from the tool, for the site n.3

Net present value (NPV)	3 421 083	[€]
Updated performance index	0.61	[-]
Equal benefit cost updated per	8.86	[years]
Pay Back Period	11.81	[years]
Benefit - costs rate	**1.41**	**[-]**

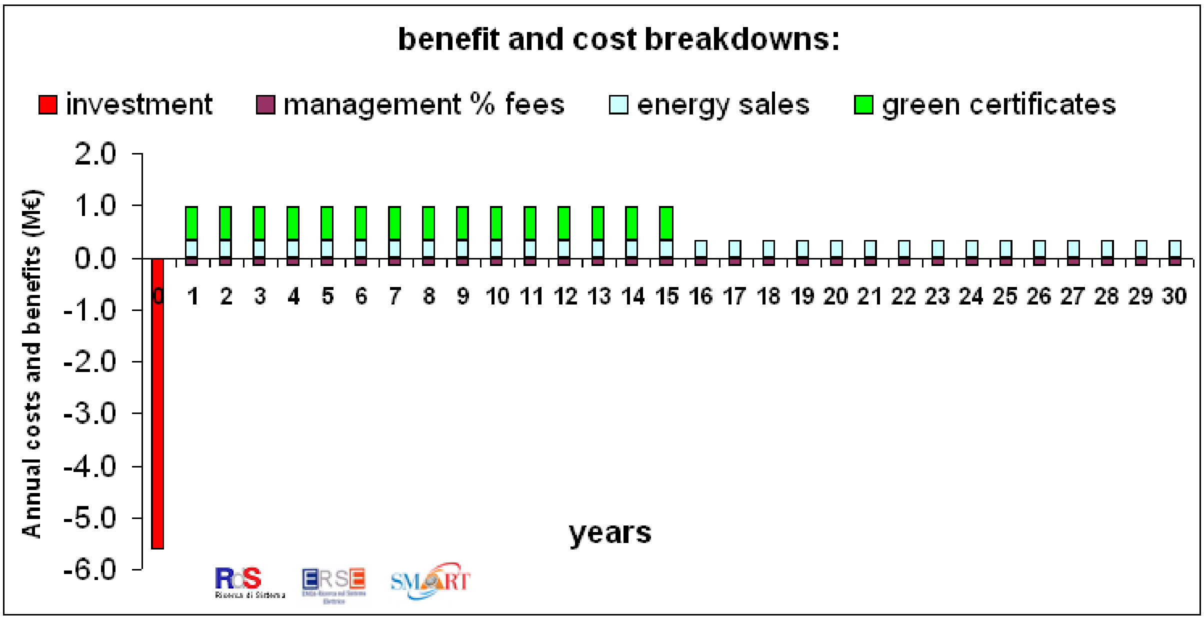

Figure 11 – Site n.3 financial parameters and cost breakdowns

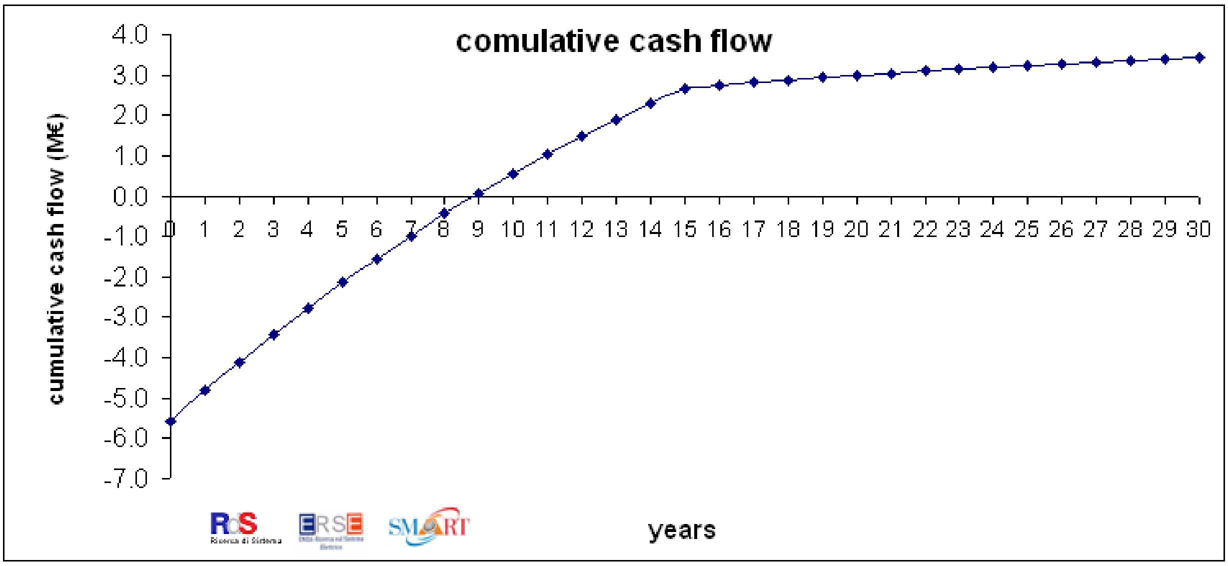

Figure 12 – Site n.3 Cumulative cash flow

2.3 Acquired experience with the Database and Public Cadastre in the web

The geographical information systems (GIS) in recent years have made possible the consultation of various kinds of spatial information otherwise relegated in reports or printed maps difficult to use.

The available technology has made it possible to overlay spatial information extraction and processing of data calculations with spatially distributed parameters.

In addition to these opportunities has further developed the technology that made possible the widespread distribution of spatial information through the Internet with so-called WebGIS.

This environment also allows less experienced users to navigate the map simply by having available a browser connected to the Internet and view and download detailed information available.

In this context was developed the SMART WebGIS application using open source (public domain) software, based on data provided by various partners. The choice of using non-commercial software products but a public domain platform, was characterized mainly by two factors:

- the acquisition of expertise in the category products
- the opportunity by all project partners to acquire data and application at no cost to dispose of any within their own organizations, without having to refer to commercial platforms having high costs.

The application was developed on the MapServer software platform, WebGIS product with pmapper GUI, which is supported by an Apache Web Server.

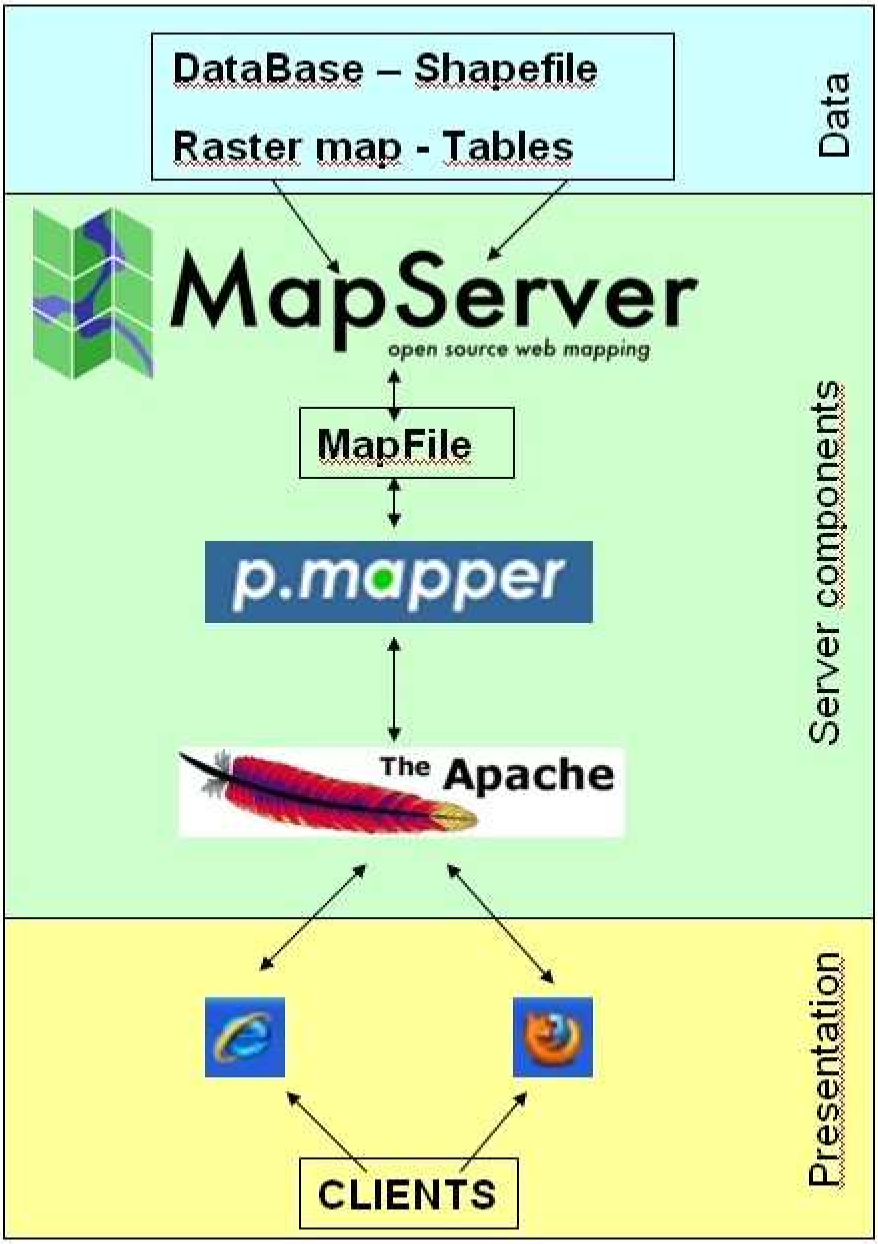

Figure 13 – WebGIS components

The available data are stored in different formats, namely:

- Database Microsoft Access
- Esri Shapefile
- Georeferenced raster maps

- Tables
- Images
- Pdf documents

It was originally intended to use one type of data, like the database associated with the shapefile, allowing a single structure of data and a homogeneous representation form for all partners. Given then a lack of uniform data and delayed delivery times, has changed the structure, splitting application access to data for each study area independently of each other, remaining always inside of the same WebGIS interface.

In the specific case of Italy and Cremona pilot region, national data are grouped by primary administrative units such as Regions, Provinces and Municipalities, while in the study area are represented in a timely large scale mapping. It has chosen to divide the representation into two distinct modes.

In the first case data are stored in a database and are associated with primitive graphics relating to administrative boundaries, so data mining is done by queries and joins across multiple tables, and are represented by the theming of polygonal areas according to different parameters with representation details related to display scale.

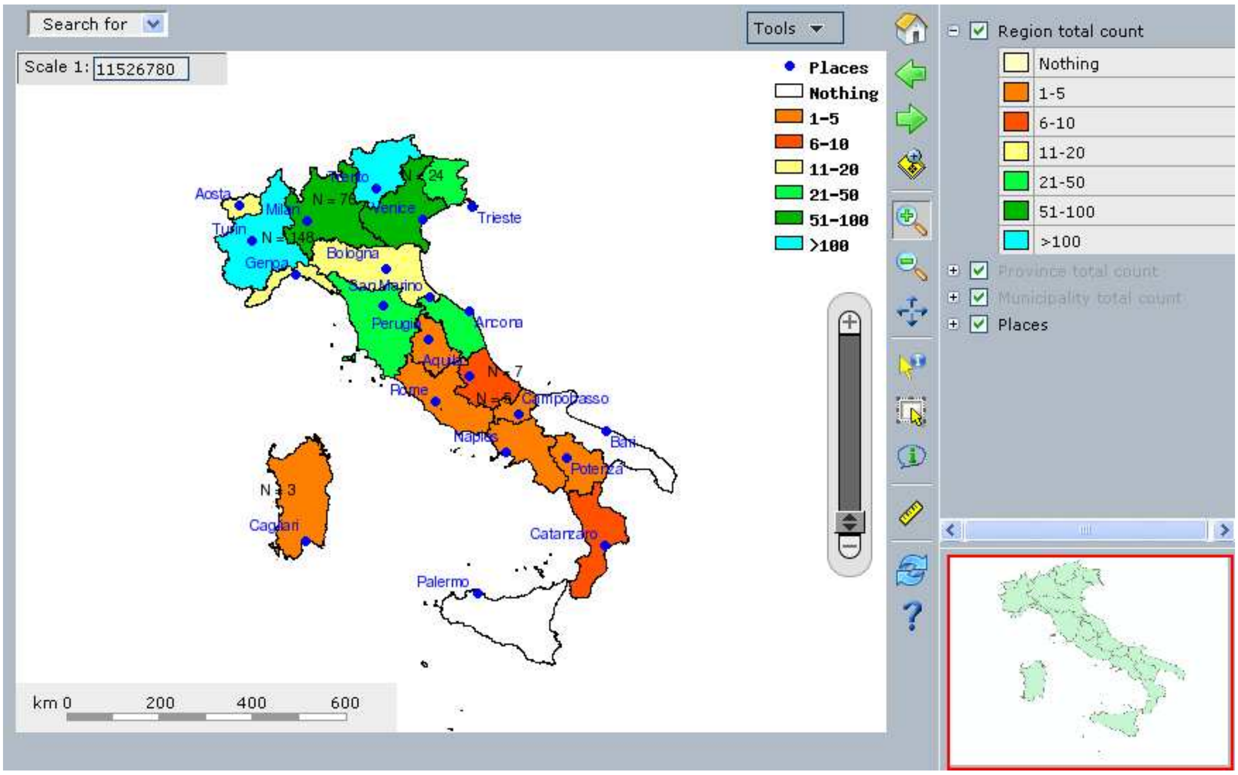

Figure 14 – Italy data representation

In the case of the pilot region, data are stored in a shapefile format with the needed associated information to access the site details data. The location of various surveyed sites is made on scale 1:10.000 Regional technical map, and is supported by the addition branches of rivers and channels present in the area.

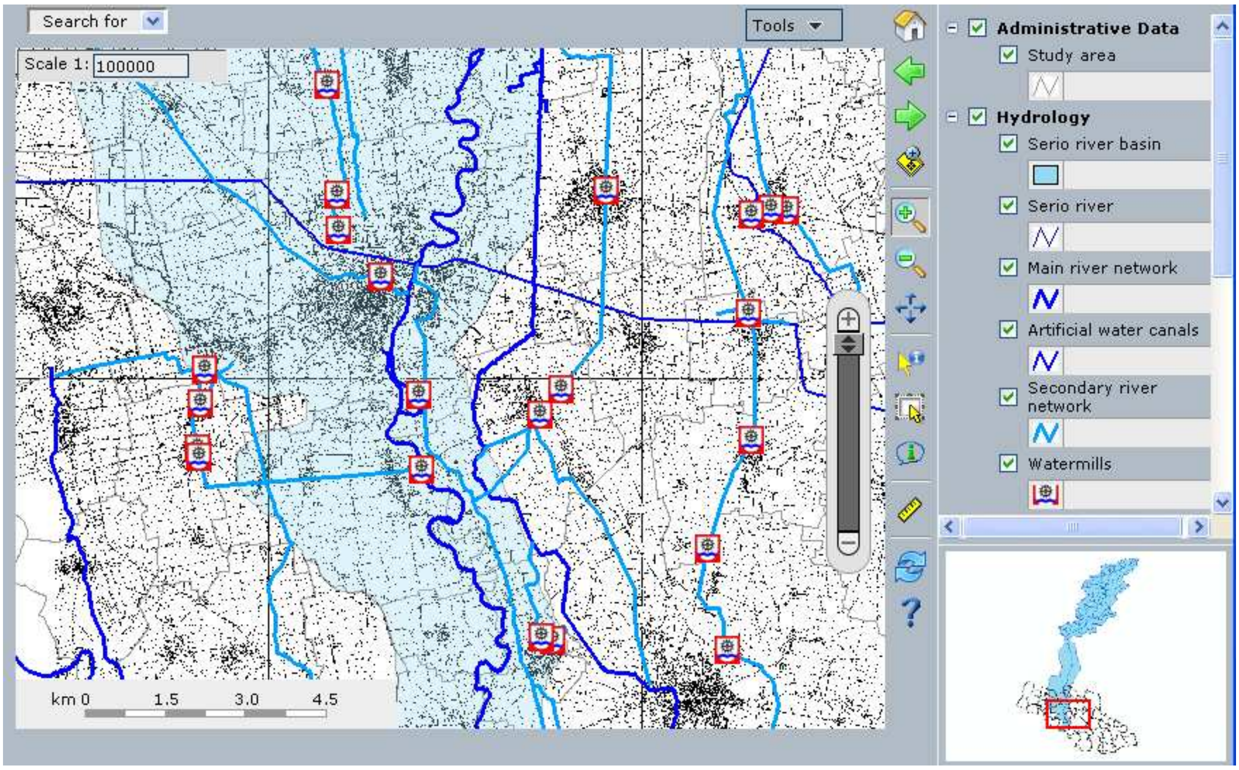

Figure 15 – Cremona pilot region data representation

Once the site of interest was identified using a dedicated searching tool, it is possible to access to the information sheets of the potential minihydro power plant sites, saved locally.

Cod. ID : 1

Mulino da grano ad acqua in loc. MOLINO SONCINO (Castelleone).

Descrizione sito:

Questo complesso è localizzato lungo la strada provinciale Castelleone – Romanengo, sulla sponda della roggia Maltraversa. Attualmente è utilizzato in parte come abitazione e in parte per altre attività (ristorazione). La ruota è presente ma non più funzionante in quanto attualmente svolge solo funzioni decorative per l'attiguo ristorante.

Potenza stimata dell'impianto: ***13.33 kW***

Figure 16 – Information sheet of a potential minihydro power plant site

2.4 Acquired experience with the Concessions

2.4.1 Application of a new administrative procedure

The analysis of the legislation carried out in the project and presented into the manual has highlighted how non-technological barriers are the reason for the lack of development and exploitation of mini hydropower in Italy. The current legislation does not differentiate procedures according to the plant power, causing a disadvantage for smaller stations. The investors, whether they should build a hydropower plant or restore an old mill, face the following procedures necessary for the correct commissioning of a power station:

- Environmental Impact Analysis (L.D. 152/2006);

- Granting of the concession of water withdrawal for hydroelectric purposes (T.U. 1775/33, in Lombardy R.R. 2/2006);
- Unified authorization (L.D. 387/2003);
- Connection to the mains (DPR 327/2001).

Lombardy, through its regional regulation, has already tried to align the rules regarding the environmental impact assessment procedure with the one relating to the granting of the concession, provided by the law 241/90. The attempt has been proved to be hardly applicable, especially in implementing particular aspects regarding the management and organization of joint procedures. Currently the competence is shared between the Provinces (small water withdrawal concessions) and the Region (EIA procedures). The overcoming of difficulties is conceivable in the implementation of the proposed delegation of powers to the provinces relating to the EIA.

The bureaucratic time of the main procedures limited to the case of Lombardy, where the Province of Cremona acts, could be listed as follows:

a) Derivation Grant (RR 2/2006): the concession can be issued within 18 months, becoming 24 if the plant is subject to EIA or in case of competing submissions;

b) Arrangement of the Final Draft (RR 2/2006): once obtained the concession, the party nominee should prepare a final draft evaluated by Public Authorities in order to gain the authorization for plant construction and commissioning. The time of execution of the final draft is fixed by the grantor;

c) Unified authorization (art. 12 L.D. 387/2003): the final draft is submitted to the investigation for the achievement of the authorization for the construction and commissioning of the plant. The legislation provides 180 days from the submission of the enrollment application;

d) Authorization for the connection to the mains (art. 52 quater DPR 327/2001): when the applicant matches the subject of the concession holder, the procedure can be avoided by including it into the unified authorization. By the way, the applicant is often different (ENEL, for instance) and the issuance of the authorization lasts generally 180 days.

In conclusion, the time between the submission of the first enrollment application and the beginning of plant construction may not be less than 900 days (except for –rare- projects not subject to EIA, without competitors, and final draft coinciding with the rough draft of the concession).

During a period of three years, the investors are required to produce a significant amount of documentation (concession drafts, EIA, unified authorization, connection to the mains). Moreover, three years can be considered as a minimum, without the inclusion of process interruptions due to requests for additional documentation.

The proceedings require considerable investment costs for the companies and in some cases the technology of the original plan becomes obsolete, forcing the applicant to apply for a modification of the concession obtained. Public authorities, even with great work efforts, are inefficient and ineffective. The purpose of the proponents is to create an instrument for the optimization and coordination of procedures since existing national and regional standards cannot be modified. The proposal does not involve the elimination of mandatory steps required by the regulations, but through the application of existing rules relating to administrative procedures, identifies a methodology avoiding the duplication of assessments and reducing the number of drafts examined by public authorities. This is possible due to the clarification of the necessary steps for the planning and development of a unified draft including all information functional to the obtainment of concessions and authorizations:

a) Implementation of the Preliminary Conference of Services (L. 241/90, ART. 14 BIS): the applicant (company) may voluntarily apply for a Conference of Services in which the first draft of the conceptual design is revised by all public authorities involved, giving their responsible opinion on any necessary procedures for the construction and commissioning of a plant. The masterplan will contain: basic information required by Art. 11, R.R. n. 2/2006 (concerning the granting to the derivation); receipts of the expenses for the preliminary review and publication (Art. 14_bis – 241/1990); information referring to Art. 12 L.387/2003 (road works, power line and electric works, mitigation of the environmental impact, sanitation and maintainer rooms (ASL for instance), compliance with planning (zoning), noise pollution, issues related to the property (local plans applied, right of possession, etc.). The purpose of the conference is the preliminary participation of all public authorities involved into the process in order to highlight the limits of the project and how they can possibly be overcome by identifing the contents of the final draft (mandatory for the submission).

b) Consider Building Plans as Definite Project Plans (ART. 21 RR 2/2006): the legislation on concessions contemplates the preparation of a definite project plan (regulated by Ministerial Decree 16 December 1923), revised by public authorities involved, to obtain the unified authorization. Competing applications will be equally assessed (according to the directions of the decree), with the purpose of an easy and clear determination of the winning project.

c) Convocation of a Unified Conference of Services for all proceedings occurring: the granting of a concession for water derivation and related permissions for plant construction involve several entities, often identical. An efficient coordination of individual procedures (concession, EIA, unified authorization) requires the convocation of a Unified Conference of Services for all proceedings, eliminating duplication and allowing the applicant to submit a single plan containing all information requested by all the procedures.

As a consequence, a unique integration will be requested (if necessary), with a significant time saving. The application of the new administrative instrument will be examined in the following paragraph. The applicant voluntarily apply for the Preliminary Conference of Services whose aim is the project review within 125 days. The company or companies, in the event of competing applications, will present a final draft (valid for the concession, the EIA, the unified authorization, and the electrical connection) within 300 days.

In cases where competing applications are not presented, the issuance of the concession and the unified authorization occurs within 430 days.

In cases where competing applications are presented, the concession will be granted within 400 days, together with the refusal of the other applications, and the unified authorization will be issued within 480 days.

As a consequence, there is a crucial reduction of administrative time: it goes from a minimim of 900 days to 400 or a maximum of 480 days. Moreover, two projects are presented instead of several.

2.4.2 Analysis of study cases carried out by the Province

CASE	ONE

TOWN	Volongo, on Gambara River
PLANTS	Two competing applications with the following specifications: Faciliy 1): 2,6mc/s flow rate, 3,87m gross head, 98,65kW rated power; application submitted November 27, 2008. Facility 2): 1,651mc/s flow rate , 3,85 m gross head, 62,32 kW rated power; application submitted June 25, 2009.
DECRIPTION	The facility No.1 submitted the application for the unified authorization on November 27, 2008. The procedure has been suspended, pending the outcome of the competing project. The management of the competition has proceeded according to the steps of the instrument presented: convocation of public authorities for both competing applications, identifying a time limit for submitting the final draft. When the winning project will be determined, the second step will be the convocation of the unified conference of services for the concession and the unified authorization. In this case, the preliminary conference of services has not been applied since its activation depends on the applicant will. The long time spent between the submission of the request and the convocation of the unified conference of services for competing applications demonstrates the significant benefit of the preliminary conference. The time loss has been caused by the Public Administration, requesting additional clarification and integrations in fact postponing the publication of the request. When the application has been published, the instance of a competitor has been submitted and examined (including its additional integrations). Since the legislation contemplates a joint management of competing applications, both requests have been delayed because of the requirement of integrations. The whole procedure has been included into the proposed instrument by indicating a deadline for the submission of the final draft for both competing parties (the final draft previously mentioned within 300 days). **The commitment to implement the procedure will lead to respect the term of 100days between the submission of the final draft and the concession grant, and the additional 80days for issuing the authorization. If it will be assessed, the effectiveness of the instrument will be demonstrated.**

CASE	**TWO**
TOWN	Montodine, on Serio River
PLANTS	Application for the modification of a concession for a plant with the following specifications: 15,0mc/s average flow rate, 2,85 m gross head, 420 kW rated power.
DESCRIPTION	The application was submitted in March 2008, integrated in March 2009 with a final draft: the process (following the rules previously presented) can be assumed to start from that date. The public offices have been coordinated in a unified conference of services for both concession and authorization. The conference was successfully held

	February 20, 2009, with the obtaining of the concession by Decree of the Environmental Department Director (Province of Cremona) No 313, April 16, 2009- and the unified authorization on May 15, 2010 by Decree No 419; the facility is currently under construction. The instrument conceived by SMART has been effective, demonstrating the feasibility of the proposal: it has allowed the simultaneous analysis of the section concerning water use in accordance with local regulations governing the instream flow, the impact and the aesthetics of the construction, the compatibility of the plant in compliance with the urban local plan (PGT), the impact of the work required to connect the station to the local electricity network (medium-voltage underground power line). **The result is the simultaneous emission of two decrees (concession and authorization) concerning crucial aspects of mini hydropower stations, with considerable benefits for the requesting company.**

CASE	**THREE**
TOWN	Dovera, on Chignola Vecchia and Dovarola Rivers
PLANT	Application submitted November 12, 2007: plant exploiting 150 l/s average flow rate, 2,70m gross head, 10.50kW rated power.
DESCRIPTION	The application is pending due to mandatory integrations; once accepted, the procedure assumed for all the other study cases will follow. As for some other applications, the preliminary conference of services has not been implemented.

CASE	**FOUR**
TOWN	Isola Dovarese, on Oglio River
PLANT	Power plants inside the town: 32,170 mc/s average flow rate, 2,90 m gross head, 915 kW rated power.
DESCRIPTION	The application was submitted June 1, 2005 and integrated several times to obtain the concession on 16/12/2009 by Decree No. 1185. The whole process started long time before SMART project so that the procedure for the convocation of the preliminary conference of services has not been adopted. . On the other side, SMART proposal has been implemented in the procedure for the construction authorization: the company has submitted, at the same time, the request for the construction of the power station and the underground medium-voltage power line in order to carry out a unified conference of services (for the concession and unified authorization) early in the year 2011.

	The instrument conceived by SMART has been effective: it allowed the simultaneous analysis of the power plant as a structure (compliance with the local use assumed by PGT), the impact and the aesthetics of the construction, the impact of the work required to connect the station to the local electricity network (medium-voltage underground power line). The result will be the issuance of a single (unified) act for the authorization of the construction of the power station and the underground medium-voltage power line.

2.4.2 Drafting and implementation of a small hydroelectric gross heads register

Among the actions implemented into the SMART project, the Polytechnic of Milan, Cremona section (Doct. Escobar and Doct. Mancini) – has drawn up a register of small mills currently located in Cremona territory: there are 21 sites potentially convertible to power stations since the presence of water has been detected (but not measured). After the presentation of the register at least four companies have submitted a letter to the Province explaining the intent to construct mini hydroelectric plants in some of these sites (Polytechnic of Milan – Department of Industrial Engineering and Management, Microidro Ltd., SCS Idro Ltd., Energyca).

A first practical application of the current technology has been highlighted in the study carried out by Microidro Ltd.. The company has submitted to the Province of Cremona in December 2010 a plan for the development of small hydropower sites in a notice issued by the province itself, which requires the preparation of a detailed analysis on new types of electrical connection to the local network; in particular, the analysis insists on the use of power electronics and is referred at least to two of the twenty-one potential mini hydroelectric sites located in the Province of Cremona and registered by SMART project. The selected sites for the analysis are:

- **Mill on Capri dimple spring, located in Pieranica (CR);**

- **Razzica Mill on Marinona canal, located in Romanengo (CR**).

A final and accurate study is already available for both mills where the possibility to convert mills into mini hydropower stations is presented. The analysis will be benefited from the adoption of the regional resolution DGR No. 8/10622 of 25 November 2009.

2.4.3 Cooperation with the regional authority

One of the most important action was the collaboration with the Regional Authority of Lombardia that is the delegated authority from Italian Parliament to make laws in the field of concession to use water on its territory.

In fact, Cremona’s offices, during but expecially after the end of the handbook making (2009), started a collaboration with the regional offices on the application, of the suggestions’s handbook, in the new regional rules on concession, with the aim to improve the local administrative procedures. The regional officers had many contacts with the Provinces and they came in Cremona in occasion of the national meeting of 2009 held by Province of Cremona on mini hydro and they demostrated to be ready to collaborate with Cremona on the new rules. Unfortunately, the Regional elections of 2010 suspended this framework and at the end of 2010 Regional offices declared to need to start again because the new regional council. However the suggestions of our thith chapter seem liked from the regional officers almost on many points.

Also, Province of Cremona has directly participated to the technical coordination meetings for the preparation of regional guidelines approved by DGR No. 8/10622 of November 2009.

The coordination meetings were compiled by officials of all the Provinces of Lombardy and had the clear objective to estabilish and approve the first **"Regional guidelines for the authorization of power plants from renewable energy sources (RES)".**

The issue of the concessions has not been analyzed in the meetings since it is considered a separate chapter, even if concession itself is a crucial part of the unified authorization for the construction of a power plant with rated power licensed higher than 100kW. In particular, the role of engineers Antoniazzi and Galloni, attending the meetings in 2008-2009, appointed members of the working tables by Decree No. 1871 of February 26, 2009, was to point out and require that the connection of the power station was treated with the plant itself, with the purpose to simplify and streamline procedures for authorizing the construction.

The result of such actions, agreed with all the other Provinces, was the drafting of guidelines, requiring at art. 6.4 that the layout issued by ENEL must be acquired at the start up of the proceedings or during the official document review. By the way, ENEL plan must be integrated into the authorization proceedings of the whole power plant.

2.5 Conclusions

VAPIDRO-ASTE and the SMART Mini-Idro tools were successfully applied to the Cremona pilot area rivers Serio and Adda.

The results of the VAPIDRO-ASTE calculation regarded 5 potential hydropower sites in the Serio river and 1 site in the Adda river. After a field visit, resulted that 2 potential sites are currently reserved by hydroelectric concessions (Montodine and Crema). Montonine mini hydro plant is under construction demonstrating that VAPIDRO-ASTE was able to identify with precision the future hydropower locations.

The comparison between the constructive and the calculated parameters of the Montodine mini hydro plant confirmed the goodness of the VAPIDRO-ASTE modelization.

The site n.3 in the River Serio was established as the best free site where to build a new mini hydro plant.

These tools demonstrated to be a quite helpful support to administrations, decision makers and stakeholders in general, to make Energy Master Plans, or assess small scale hydropower plants.

Database and WebGIS helped to collect data otherwise distributed in different archives. Database, especially with regard to Italy, made it possible to have an overview of power plants distribution with a high spatial detail.

WebGIS (http://smart.erse-web.it:8082/smart) helped to collect accurate information, particularly concerning the hydropower potential sites of all partner's nations.

Development of a WebGIS application has also contributed to understand the open source tools and to allow its use at no additional cost.

Regarding the concessions, the study cases underline the need for maximum dissemination of the proposed instrument (first presentation in September 2009, Forum of Naples). In particular, company interested into the development of mini hydropower plants need to know about the preliminary conference of services instrument. The legislation is nowadays complex and forces companies to chase individual offices, aggravating a considerably demanding procedure.

Conversely, the dissemination of a clear instrument highlighting the proceedings necessary to achieve the commissioning of a plant will help the applicants and public authorities to assess from the outset all critical aspects of a plant realization, avoiding inconsistent projects in conflict with existing development plans.

The preliminary conference of services, which aims at this objective, must be interpreted not as a burden complicating the procedure, but as a confrontation and effective collaboration with public authorities to overcome bureaucratic and technical issues. The cooperation between offices, in particular between the managers of the most important procedures, has been crucial: concession, environmental impact analysis, unified authorization, power line connection. In the future, the same approach will be paramount for a successful dissemination of the instrument proposed. The commitment will be necessary for all authorities and applicants involved into the proceedings.

A successful interest has been shown by the companies involved in the experiment, subjects beliving in the instrument even if partially applicable and glimpsing the possibility of reducing time and encouraging the submission of a single project reviewed and approved by all public authorities.

Competing applications and different interests on the same resource (irrigation and hydroelectric purposes for instance) cannot be overcome through a coordination of procedures; they need to find a codified and determined legal dimension, without misunderstanding.

As a consequence, there will not be bureaucratic time extensions and additional workload for the offices.

The systematic application of the procedures proposed will certainly standardize the relationship between individual departments making them independent of the will of operators, offering success guarantees. The dissemination of the information to applicants and authorities will assure a widespread awareness of the instrument achieving more and more effectiveness and efficiency.

3 STRATEGIC ACTIONS – CROATIA – KARLOVAC COUNTY PILOT REGION

3.1 Introduction

Strategic actions learned on the Karlovac County pilot region fall in the area of:

- legislation;
- current state of the art in the construction of small hydro turbines and small hydropower plants (SHP);
- hydro potential determination of a catchment area and techno-economic analysis of SHP projects;
- environmental protection, and
- dissemination (promotional) activities.

During the development of SHP projects in the Karlovac County pilot region some weak and strong points of the Croatian legislation have been determined, which refer on the entire process from seeking a concession for water use and building permits for SHP up to conection of SHP on the electric grid. Based on the analysis of weak and strong points in both the Republic of Croatia and in the partner countries in the SMART project, the suggestions to improve the legislation relating to the construction of SHP in the partner countries and beyond in the EC are proposed.

Locations for SHP in the Karlovac County pilot region are characterized by small heads and relatively large flows. On the other hand the spatial plan of Karlovac County does not allow raising of the dam with crest of more than 3 to 5 m. Investigations of possible types of water turbines for such applications suggest the application of turbines for a very low heads, the so-called very low head (VLH) technology, which have been developed in recent times.

Measurements of the flows of rivers in the Karlovac County does not exist for all potential sites for SHPs, so there are difficulties with the determination of flow duration curves i.e. their potential. So far, they are used in such cases, very approximate methods, and optimization of the position for a small hydroelectric power station was not an option. The most common is based on decades of experience through a series of positions used for the mills. Now, through the project FSBUZ has the option of software using which are developed by the project partners.

Also, until recently, carried out the techno-economic analysis of potential locations for small hydropower plants were not sufficiently comprehensive. Clearly, the assessments that followed from them were questionable. Through the project the standard for soft-wares usage for techno-economic analysis is set, which are developed by partners in the project or which can be found on the Internet and use for free.

Today, the technologies for minimizing of SHPs impact on the environment, primarily on fish life are developed. VLH turbines are friendly to fish life. Also, constructions of fish ladders (fish trails) are improved and applicable for most locations. Also, garbage collection by trashracks and disposal carried out at a SHP can serve to clean up a river.

Workshops, articles in newspapers and magazines, broadcasts on television and radio, the papers presented at symposiums and conferences contribute to the popularization and increasing interest of investors and developers for SHP. It also leads to knowledge increase of the administration responsible for the implementation of legislation related to the SHP.

Foregoing will be described below.

3.2 Legislation

Within Work Package 2 (WP 2) project partners are assessed weak and strong points of legal procedures in respect of SHP in their countries. For the Republic of Croatia are determined the following weak points of different regulations:

1) The process of preparing and construction of SHP is a very complex organizational process. The whole process can be divided in various phases, each phase comprising the basic legal acts resulting from activities carried out in a particular phase. Each phase consists of several activities resulting in fact that 19 basic legislative acts request a total of ca. 48 activities. It is necessary to procure and pay about 67 different documents in several institutions. Part of the process is additionally complicated by the duplication and repetition of documents;

2) The process is the same for all renewable energy sources and for different powers of plants (from a few kilowatts to 10 megawatts);

3) For location permit it is necessary to demand a grade about the need to carry out a study about environmental impact and a study about nature impact. It is not clearly defined what these demands need to contain and who is responsible for them. Neither have the criteria determine whether these studies are necessary or not been clearly defined;

4) For location permit it is necessary to contribute an SHP conceptual project whose contents and volume are not known;

5) Resolution of proprietary-legal relations on land is not stipulated at all to request a building permit. Thus the applicant may invest a lot of money and have not guarantee of a positive solution of proprietary-legal relation;

6) A tax of 7.5% exsists only on net profit from SHP (out of all plants on renewable energy sources);

7) For SHPs exceeding 5 to 20 MW Water Law determine a concession of up to 60 years while for SHP up to 5 MW the concession is up to 30 years;

8) Lack of reliable data about water resources – incomplete SHP cadastre, *and strong points:*

1) Water is considered as a public resource;

2) All regulations are on the national level, not on regional level;

3) By work of the Ministry of Economy, Labour and Entrepreneurship (MoELE) through different projects, work-shops and publications (in this number also the web site: www.mingorp.hr), so the complex process is more understandable, transparent and straight.

Based on the analysis of weak and strong points in the partner countries in the SMART project, the suggestions to improve the legislation relating to the construction of SHP in the partner countries and beyond in the EC are proposed:

1) Suggest the use of conference of concerned bodies for all partner countries;

2) Fix a list of documents: essential preliminary documentation and after conference of concerned bodies the detailed documents;

3) Fix a time limit of the procedures from the presentation of the application until the authorization to build and operate the plant (water concession procedure included);

4) Master plan concerning water use for power generation;

5) Suggest different procedures in according to the size of the plant (100 kW);

6) Special state financial support for SHP;

7) A common unification of licenses procedures (water permission, power plant, power line);

8) Quality logistics in licensing (web-site);

9) For the grid owners: force to connect the SHP to the electric grid;

10) Public contact points: suggestion to promote the best sites and after open a call for tenders.

3.3 Current state of the art in the construction of small hydro turbines and small hydropower plants (SHP)

Low-head hydro has the potential to generate green energy with only a minimal impact on the environment. While world wide hydro potential is vast (thousands of suitable existing dams), the development of this potential is very low due to its high development cost, particularly for the related civil works which represent 40-50% of the total development costs of any given project.

Traditionally, the R&D effort of the large turbine manufacturers has been toward the reduction of the turbine runner diameter in order to reduce the equipment costs while maintaining high turbine performance. They certainly succeeded in their efforts as we now have on the market very efficient, high speed turbines with small runner diameter. Small turbine being a scale down of large turbine technology, the consequence is that the cost of the associated inlet and outlet concrete works required to convey the water from the intake to the runner and to recover the kinetic energy existing at the runner exit becomes excessive in very low head situations.

A new turbine concept (the VLH turbine) is designed specifically for very low head sites (1.4 to 3 meters net head). The objectives of the designers of the VLH turbine was to develop a unit that will require very few civil work, will be easy to install and will offer a high degree of reliability at a reasonable cost per installed kW. To achieve these goals, the VLH concept takes a completely different approach from the traditional turbine design, using large runners to practically eliminate the expensive civil structures of the traditional concept. This revolutionary new concept integrates the most advanced technologies available in the power generating sector such as directly driven variable speed permanent magnet generator, power electronic, integrated computerised control system, and single screen man machine interface. It addresses the most demanding environmental integration conditions in terms of noise, vibration, fish migration through the running turbine, or visual impact.

The first industrial prototype has been successfully installed and commissioned in March 2007 in demonstration site of Millau (Centre south of France).

3.3.1 The VLH turbine concept

The development of low head sites is done using the classical approach i.e. with vertical Kaplan turbines, bulbs units or pit structures. When it comes to very low head sites (below 3.2 m), the complex civil structures required to direct the water from the intake to the runner and to recover the kinetic energy contained in water at the runner exit are too expensive and make it impossible to economically develop such sites.

The VLH concept is innovative. The approach is to have integrated generating set build around a large Kaplan runner directly coupled to the generator, the trash rack and trash rack cleaner all integrated in one block installed in sluice passage of existing dams. The large runner diameter running slowly, the water velocity at both end of the turbine is reduced and the needs for complex civil structures are eliminated. The difference in civil structure requirements between the classical approach and the VLH solution is well illustrated in the figure below.

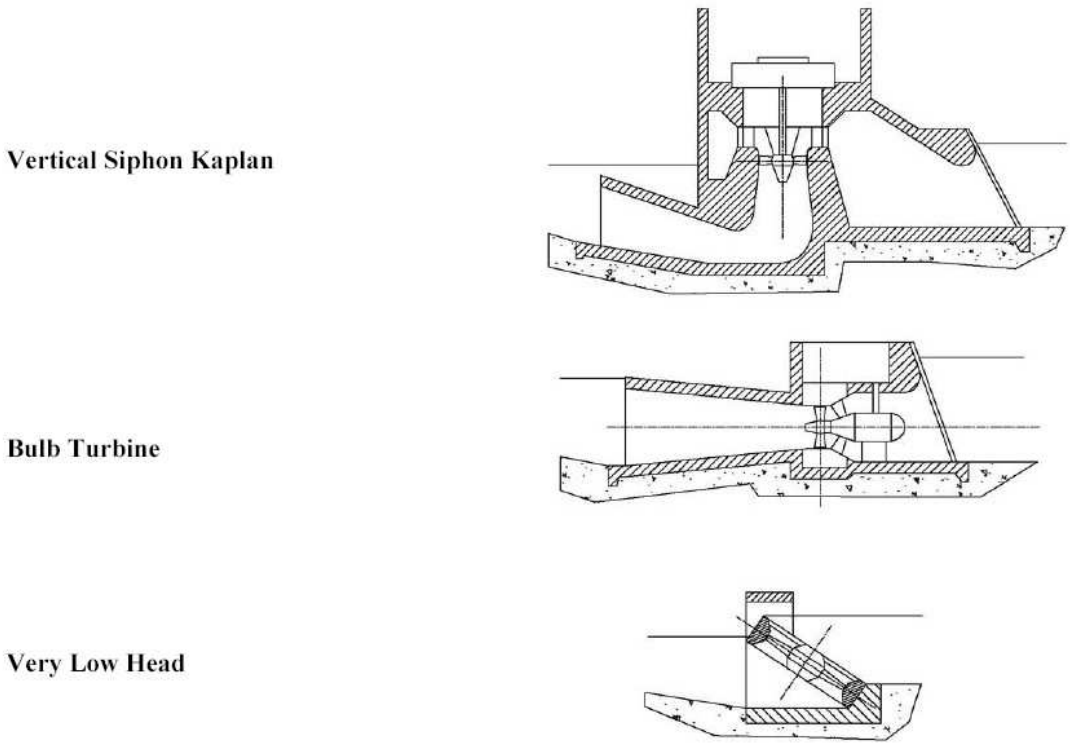

Figure 17 – The difference in civil structure requirements between the classical approach and the VLH solution

The 3 examples above are using the same water head and are designed at the same scale. They respect propeller diameter and civil works dimensions for the same head and flows characteristics. The extend and complexity of civil works for each case is self explanatory. A statistical and mathematical survey developed on hundreds of low head sites is showing that there is a direct link between head reduction and concrete volume rise: the result is that, considering a constant output, if the head drops from 3.2 m to 1.4 m, the corresponding concrete volume required to build the power plant is multiplied by 5, while the runner diameter of the turbine is doubled, as it presented on the next figure. This is the reason why very low head sites are technically feasible but unprofitable.

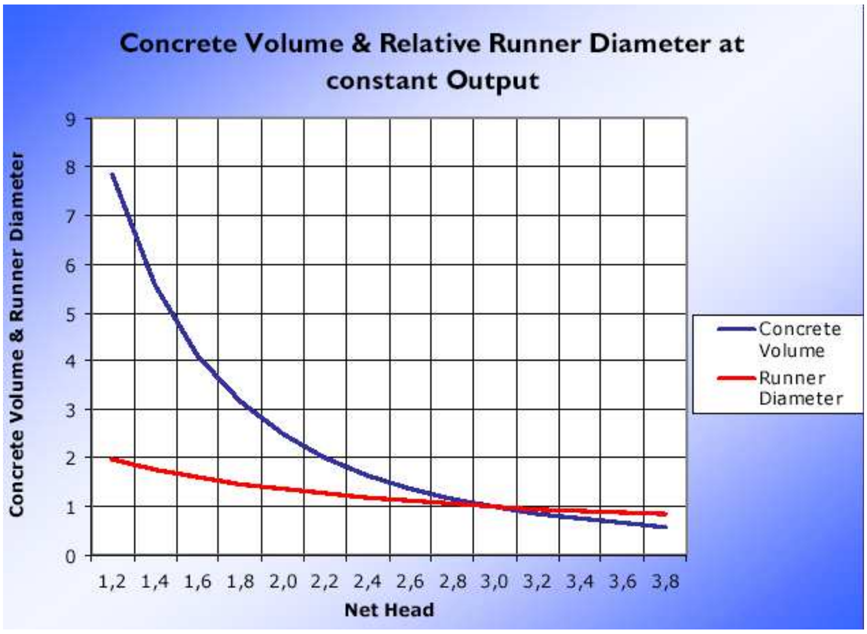

Figure 18 – Concrete volume and runner diameter at constant output v.s. net head at low head sites

3.3.2 The VLH turbine description

The VLH is an Integrated Generating Set (IGS) that incorporates an 8 adjustable blades Kaplan runner, a fix distributor composed of 18 wicket gates with flat bars inserted in between as trash rack, a permanent magnet variable speed generator (PMG) directly coupled to the runner shaft and an automatic trash rack cleaner mounted on the distributor, as it is presented on the next figure.

As the runner of the VLH is large, the speed of the water through the runner is slow and the needs for a sophisticated civil structure at the inlet and at the exit of the runner are eliminated. The low rotational speed of the runner and its low velocity of water make the VLH a fish friendly turbine.

The IGS is entirely submersible allowing a very silent operation and almost no visual impact. It is mounted slanted and can be removed from the sluice passage way by a lifting system so the unit can be raised (or translated) for maintenance or to recuperate the full evacuation capacity of the sluice during high flow.

The runner blades are adjustable and self closing allowing automatic upstream water level regulation and eliminating the needs for a separate closing gate to shut the unit. The unit can also operate in discharge mode (when unit is not generating electricity) and will be able to operate isolated from the distribution network. Furthermore, its extremely low rotational speed (less than 40 rpm), large runner diameter (from 3.55 m up to 5.6 m), very low water velocity (less than 2 m/s) together with other patented technical features makes it a fish friendly turbine which will allow fish migration through the turbine runner itself downstream and possibly upstream too.

The VLH turbine concept is not a specific site design. A standardized product range has been established (5 runner diameter size are available) and the generator output range is between 100 to 500 kW for heads ranging from 1.4 to 3 meters and flows from 10 up to 30 cubic meters per second. The VLH turbine generating set is double regulated (adjustable blades and variable speed). This characteristic allows operation on sites where the head drops with variation of the flow. Furthermore, the variable speed capability of the VLH turbine generating set assures a stable and efficient operation under variable head. The VLH is able to work under 1/3 of the nominal head at nominal efficiency.

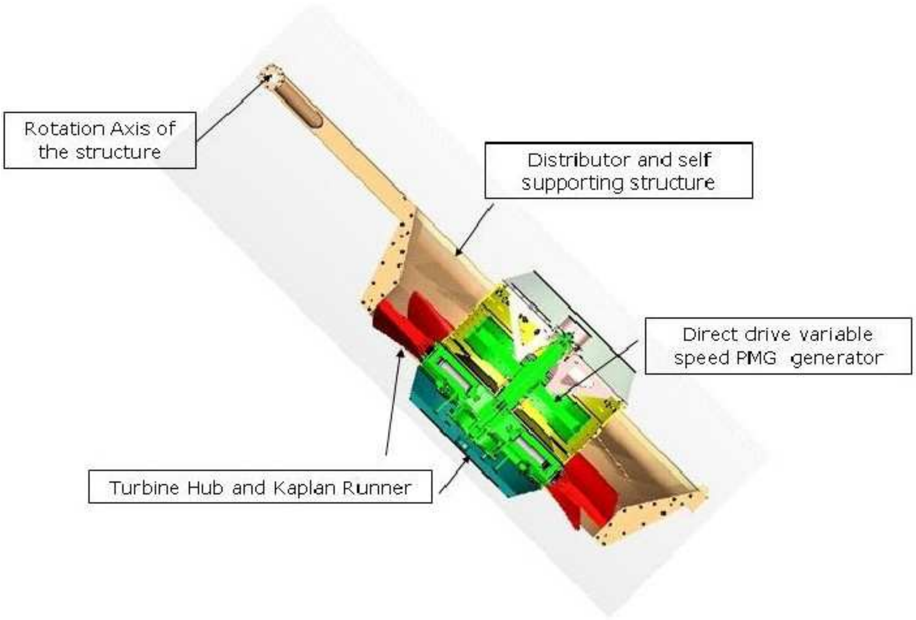

Figure 19 – The VLH Integrated Generating Set (IGS)

3.3.3 Permanent Magnet Generator and Variable Speed Operation

The VLH turbine is equipped with a Permanent Magnet Generator (PMG) directly coupled to the turbine shaft. The extremely slow speed of the VLH turbine (max. 41 rpm) generates a low frequency power (approximately 12 Hz) at the generator output. This power is then processed by the Hydroelectric Power Generation System (HPGS) that is composed of the power electronics equipment, the power controller and the power station controller and its user interface. This sophisticated electronic equipment generates energy and provide quality interconnection that meets IEC and IEEE applicable standards.

Variable speed technology has been successfully used in wind generation and this technology was adapted to the VLH turbine operation. This capability to operate in variable speed mode allows the VLH turbine to operate at near maximum efficiency under variable head down to 1/3 of the nominal head. These features offer many advantages to the VLH turbine. First, it makes it possible to generate electricity at sites where there is head variations without having to install expensive double regulated Kaplan turbine with their costly associated civil structures. Secondly, the slow speed of the turbine-generator augment the mechanical reliability and life expectation of the equipment. Thirdly, it makes the system easily adaptable to 50 and 60 Hertz standards or to isolated network operation. Finally, it has a very positive impact on fish friendliness.

3.3.4 Fish friendliness

The very special characteristics of the VLH, makes it one of the first ever designed fish friendly hydro turbine generating set. CFD optimisation of the VLH turbine has integrated at the design stage fish friendly criteria based on a survey realised by the Idaho National Engineering and Environmental Laboratory for the US Department of Energy.

The fish friendliness of the VLH turbine is also tested in-situ at the site where the prototype VLH turbine is installed. The fish passage tests conducted in several sessions. The first one has tested the downstream migration of smolts, a second series of tests tested the downstream migration of silver eels. These tests are conducted in Millau.

3.3.5 Prototype site, Millau – France

The Prototype VLH turbine is installed in Millau, France. It is presented on the next four figures. The VLH turbine has 4.5 m diameter rotor, using a 6 m wide water intake channel. The VLH set is located downstream of an old main building where electric and electronic gears and auxiliary equipment is located at the second floor above flood level. Start-up and commissioning of the Millau plant has taken place on the 19th of March 2007.

The VLH is prefabricated in a workshop. Delivery on site is done in separated sub elements, 2 distributor halves, the complete generator, and the turbine runner delivered without its blades because of its 4.5 m diameter. A flat and clean assembly zone has been prepared closed to the turbine location. The runner wheel is first positioned on prefabricated concrete blocs. Then, the runner blades are fitted on the runner wheel. Afterwards, the two half distributors are bolted on top of the runner.

The generator is finally slipped inside the distributor on top of the turbine shaft and then bolted to the VLH structure. Connection of cables, sensors and hydraulic ducts can take place.

Once assembled, the complete VLH set, (weight 26 t) is craned in a single operation inside its final location. It smoothly rotates on its 2 bearings from the horizontal position to the 15° incline position.

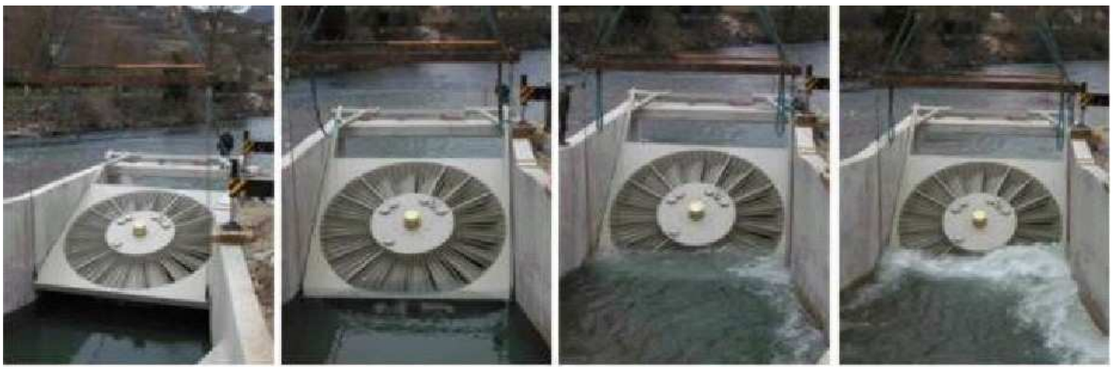

Figure 20 – Instalation of the VLH in its final location and first contact with water

Figure 21 – VLH DN 4500 runner of the Millau demonstration site

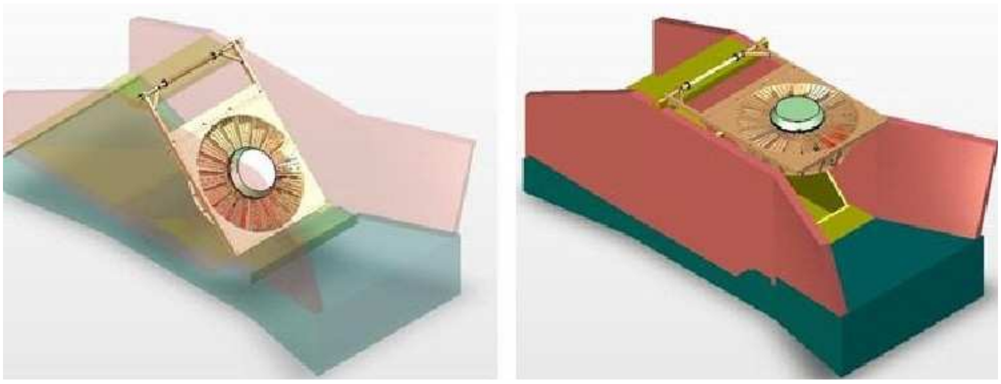

Figure 22 – Turbine in working position (left) and in withdrawn position (right)

Figure 23 – VLH in working position during the visit of 50 power plant owners

3.4 Hydro potential determination of a catchment area and techno-economic analysis of SHP projects

For hydro potential determination of a catchment area and techno-economic analysis of SHP projects the soft-wares are used, which are developed by partners in the project or which can be found on the Internet and use for free. The soft-wares are presented in detail in deliverable 3.1: Digital Handbook on methodologies and tools.

3.4.1 Department of Natural Resources Canada soft-ware

The RETScreen International Clean Energy Decision Support Centre (the RETScreenInternational Clean Energy Decision Support Centre) seeks to build the capacity of planners, decision-makers and industry to implement renewable energy and energy efficiency projects. This objective is achieved by: developing decision-making tools that reduce the cost of pre-feasibility studies; disseminating knowledge to help people make better decisions; and by training people to better analyse the technical and financial viability of possible projects.

RETScreen™ is a registered trademark of Department of Natural Resources Canada. The hydropower estimation tool is a module from the RETScreen™ International Clean Energy Project Analysis Software, a unique decision support tool developed with the contribution of numerous experts from Canadian government, industry, and academia. This public domain software was developed to assist in evaluating the energy production, life-cycle costs and greenhouse gas emission reductions for various types of energy efficient and renewable energy technologies ("RETs").

These RETScreen files contain a collection of project case studies, including assignments, worked-out solutions (RETScreen Software Analysis) and information about how the projects fared in the real world. This document includes a background of energy technology and it provides algorithms for Project Models. In addition there are many case studies that provide succinct details on various renewable installations including system descriptions, lessons learned and many other important and useful information.

The RETScreen Clean Energy Project Analysis Software is a unique decision support tool developed with the contribution of numerous experts from government, industry, and academia. The software, provided free-of-charge, can be used worldwide to evaluate the energy production and savings, costs, emission reductions, financial viability and risk for various types of Renewable-energy and Energy-efficient Technologies (RETs). The software (available in multiple languages) also includes product, project, hydrology and climate databases, a detailed user manual, and a case study based college/university-level training course, including an engineering e-textbook.

The RETScreen Software Hydro Power Model can be used worldwide to evaluate the energy production and savings, costs, emission reductions, financial viability and risk for central-grid, isolated-grid and off-grid hydro power (hydroelectric) projects, ranging in size from large dams with multi-turbines to small and mini hydro installations using weirs to small scale single-turbine micro hydro systems. The model addresses both run-of-river and water storage (reservoir) developments, and it incorporates sophisticated formulae for calculating efficiencies of a wide variety of hydro turbines, such as Kaplan, Francis, Propeller, Pelton, Turgo and Cross-flow models. In RETScreen, hydrological data are specified as a flow-duration curve, and costs can be estimated using an advanced formula costing method tool. The software (available in multiple languages) also includes product, project, hydrology and climate databases, and a detailed user manual.

RET Screen is a software developed by the Government of Canada, Department of Natural Resources and available freely over the internet at www.retscreen.net. The model is available in several languages. The purpose of the model is to compute costs and benefits, including greenhouse gas analysis, for small scale run-of-river projects. While originally intended as a tool for preliminary studies utilizing mainly map data, the latest version now allows the engineer to enter work quantities and unit costs against a comprehensive list of work items.

Once the ranges of head, flow and "best fit" equipment choices were identified, RETScreen™ is used to compute estimated capital costs. Those costs were then adjusted to US$/kW.

3.4.2 ERSE software

VAPIDRO ASTE is a GIS integrated tool to calculated the hydropower potential and identify the identification of promising small scale hydro plants sites, through the evaluation & management optimization of water availability, considering geodetic heat in the territory (at regional and basin scale).

The tool takes into account the water resources present exploitation with its geographical location and elevations (irrigation uses, drinkable water, existing hydropower plants, etc.), and the limitation that this creates regarding the potential energy patterns. The software is based on the topographic information

(Digital Elevation Model) and the isohyets maps, with a whole analysis of the catchment, together with the regional evaluation of available discharges along the river system.

Based upon a user friendly graphical interface the tool is able to split the river into a hundreds of cross sections, calculate the available discharges and potential hydropower production, considering constrains like minimum flow, withdrawals and restitutions scheme.

To realize the optimization VAPIDRO ASTE performs an economical & financial analysis of SHP plants (including green certificates and eventual governmental subsides).

The tool shows to be a quite powerful instrument to support decision makers and stakeholders, for the energy plan preparation, the assessment and the implementation of small scale hydropower plants.

SMART Mini-Idro is a tool to evaluate the main hydropower project parameters, considering the flow duration curve, the available heads and the types of turbines to be installed, the range of discharges to be used, etc.

The tool considers the possibility to apply government incentives to the investment as the "green certificates" and finally is able to evaluate the cash-flow of the investment.

The tool helps the user as a first approach to begin a preliminary project, leading to a first analysis of the economical and financial parameters of a new SHP.

The software is composed by the following 5 modules:

1) Discharge module, with the calculation of the Minimun Instream Flow, the turbined flows, etc);

2) Turbine module, with the selection of the appropriate turbine type;

3) Energy module, with the calculation of the energy produced;

4) Costs module, with the evaluation of the construction and maintenance costs;

5) Financial Analysis module, with the calculation of the financial parameters and the cash flow analysis.

3.4.3 NTNU program tools

Program tools, made for the first approach to possible SHP projects, are developed at NTNU. The programs help the user in a preliminary project to calculate the investment costs of a Small/Mini/Micro hydropower plant. This is to provide more efficient mapping of which locations of intake and powerhouse that could be the most economically profitable.

Three programs present program tools: the "SHP Global view", the "SHP Individual view" and the "SHP Optimisation Program". "SHP Global view" gives a quick overview of the costs while "SHP Optimisation program" makes an economical optimisation of the plant, based on more detailed input data. The "SHP Individual view" may be used if the user only have the necessary input information for a few of the SHP plant parts and want to have a closer look at these.

It is very important that the users of the programs understands what assumptions the calculations are based on, as well as understands how to use them correctly.

3.5 Environmental protection

Assessment of the SHP project's likely environmental effects, together with any design, construction, operational and decommissioning measures that are to be taken to minimise them, would typically cover such issues as flora, fauna, noise levels, traffic, land use, archaeology, recreation, landscape, and air and water quality.

SHP are in most cases run of river, which means that any dam is quite small, usually just a weir, and generally little or no water is stored. The civil works purely serve the function of regulating the level of the water at the intake to the hydro-plant. Therefore these installations do not have the same kind of adverse effect on the local environment as large hydro. However, some environmental problems can always be detected, notably where the water is extracted some distance upstream from where it is discharged back into the river. The short stretch of bypassed river can then run dry or look unsightly unless adequate compensation flow is allowed.

In most cases, new hydro installations are designed with sufficient water bypassing the turbines – which is not difficult except in times of low flow. Another area that requires care is the need to avoid harming fish and riverine flora and fauna, but modern turbine installations are designed with this problem in mind. Some low head systems allow fish to pass through the turbine generally unscathed, but various forms of screening (either physical screens or even electrical and ultrasonic) are also used.

3.5.1 Fish ladders

Hydro-installations on rivers populated by migrating species of fish, such as salmon or trout, are subject to special requirements as defined in the Salmon and Freshwater Fisheries Act. Migratory fish must not be ingested into the turbine (so the mesh of the trashrack must be fine enough), and there must be a water passage by-passing the hydro-plant at all times so that fish can migrate up or downstream. To allow fish to pass upstream sometimes requires the construction of a 'fish ladder'.

The figure below illustrates a common fish-ladder with vertical slots and bottom orifices that yields very good results.

Figure 24 – A common fish-ladder with vertical slots and bottom orifices

Fish-ladder is usually a series of pools one above the other, with water overflowing from the higher ones to the lower ones, so that fish can jump up from one pool to the next, figure below.

Figure 25 – Fish-ladder as series of pools one above the other, with water overflowing from the higher ones to the lower ones

3.5.2 Fish-screening

On rivers where there are important fisheries concerns, the Environment Agency will stipulate more stringent screening requirements to ensure that fish will be deterred from the turbine intake and will be diverted to a suitable by-wash. The precise fish-screening measures will be a matter for negotiation, depending on the sensitivities of the site. Where there are salmon smolts migrating downriver, it is normal for a mesh-spacing no greater than 12 mm to be required for at least three months in the spring and early summer. A fine-meshed screen will accumulate large volumes of debris and an automatic cleaner then becomes essential to keep the turbine running. A number of innovative methods for excluding fish from intakes which avoid a physical screen are being trialled. These include the use of electric currents, bubble curtains and sound waves to guide the fish away from the intake. These methods offer significant advantages to the operator by avoiding any obstruction to the flow, but are yet to find general acceptance with the Environment Agency. The Bio-Acoustic Fish Fence (BAFF) presented on the figure below uses a combination of air bubbles and sound waves to form a behavioural screen to guide fish away from hydro intakes.

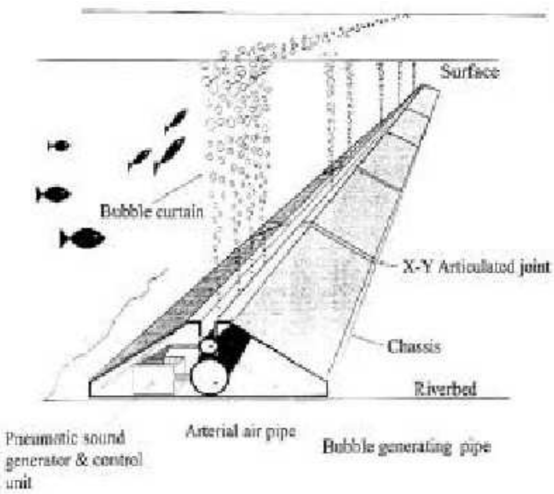

Figure 26 – The Bio-Acoustic Fish Fence (BAFF)

3.6 Screening

Turbines also need to be protected from all the debris that are commonly found in rivers, whether natural (e.g. leaves, branches, even tree trunks) or man-made (supermarket trolleys, plastic fertiliser bags or general garbage); this is done using screens. A major operating cost element is cleaning these screens, especially in low head situations where large flow rates pass through. The hydro-plant operators are usually prohibited by law from returning the rubbish collected on their screens back into the river. Thus, garbage collection and disposal carried out at a hydro plant can serve to clean up a river considerably for the benefit of everyone downstream, but usually at considerable expense to the operator.

3.6.1 Trash screens

The screen, or 'trashrack' filters out river-borne debris before it reaches the turbine. It is an extremely important component of the whole scheme, and can be one of the more expensive items. The large majority of operating problems and maintenance costs can be traced back to the screening system so investment in a robust design will pay for itself in the long run.

The first line of protection should, in most cases, be a floating boom angled across the flow upstream of the intake. This will catch large items of floating debris before they reach the trashrack. However such debris will eventually make it under the boom unless cleared within a few days.

The standard screening solution, which has been used since the days of waterwheels, is to place a rack of bars in front of the intake, with the bars spaced so that a rake can be used to drag the accumulated debris up to the top of the screen. The screen is a hindrance to the flow and introduces a slight head loss. Therefore the bar-spacing should be the maximum that will still trap debris large enough to damage the turbine. The turbine supplier will advise on the correct dimensions. In addition, the flow velocity approaching the screen should be relatively slow, preferably less than 0.3 m/s and certainly no greater than 0.5 m/s.

3.6.2 Automatic cleaners

Manual raking is only viable for small schemes, or sites which are manned for other reasons. There are now a range of automatic raking devices available to clean the screen and dispose of the trapped debris.

The most common types presented on figure below are:

A robotic rake. These come in a variety of designs, but usually involve one or more rakes operated by a hydraulic ram. Some designs require only a single rake which can index along the screen; otherwise two or more rakes can operate side by side. These systems are usually very robust, partly because they can keep their drive mechanisms out of the water at all times. Their main disadvantages are the visual presence of the equipment and the slightly greater health and safety risk posed by unattended operation of the equipment.

A rake-and-chain cleaner, in which a bar is moved up the screen by a chain drive at each end. The bar deposits the collected debris in a channel running the length of the screen. The channel can be flushed clean by a water supply (pumped if necessary), washing the debris towards a side spillway.

The grab-and-lift cleaner is a robust alternative to the robotic rake. A single set of 'jaws' indexes along the screen and lifts the material straight into a skip.

Coanda screens, applicable only for high and medium head schemes, require no raking because they utilise the Coanda Effect to filter out and flush away debris and silt particles, allowing only clean water into the intake system. Precisely positioned, finely spaced horizontal stainless steel wires are built into a carefully profiled screen which is mounted on the downstream face of the intake weir. Clean water is collected in a chamber below the screens, which is connected directly to the turbine penstock.

Figure 27 – Types of automatic cleaners

There are a few other environmental impact issues relating to oxygenation of the water, disturbance of the river bed or erosion immediately downstream of the turbine draft tubes, electrical machinery noise, electrical cables, the general appearance of an installation, etc. However, all these problems can be solved by suitable design techniques and the end product is a remarkably long-lasting, reliable and potentially economical source of clean energy.

3.7 Dissemination (promotional) activities

For the duration of the SMART project, project results were presented at workshops, in newspapers and through television and radio broadcasts. Also, the SMART project was presented at several conferences. All of this increases both the interest in SHP of investors and developers and knowledge of the administration responsible for the implementation of SHP. Currently, in RES & COGEN Projects Registry of Ministry of Economy, Labour and Entrepreneurship (MoELE) (www.mingorp.hr) in the Republic of Croatia 91 SHP projects are registered.

3.8 Conclusions

Lessons learned in the Karlovac County pilot region are as follows:

1) It is necessary to eliminate the weak points of the legislation (obstacle) which extend the legal procedures of SHP projects developments, and to accept the partners suggestions obtained on the basis of analysis of the strong points that make them easier.

2) For accurate assessment of the hydro-potential of the sites, as well as reliable techno-economic analysis of SHP projects is necessary to use the soft-wares developed by partner on project.

3) The latest VLH technology allows the use of hydro-potentials with large flow rates and relatively low geodetic heads.

4) Using modern technologies in SHP makes them acceptable for the environment (the fish friendliness of the VLH turbine, fish leaders, trashracks, etc.).

5) Dissemination activities are very important for increasing the interest of investors and developers for SHP and knowledge of the administration associated with the SHP.

3.9 References

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4 STRATEGIC ACTIONS – NORWAY – MUNICIPALITY OF MIDTRE GAULDAL AND HOLTÅLEN

4.1 Pilot Action in Norway

In the present paragraph the application of the methodology and informatic tools in the Norwegian Pilot Area in the municipalities of Midtre Gauldal and Holtålen is presented. The tools regard the evaluation of the hydropower potential, the optimization of the exploitation and the identification of the main financial characteristics of a particular site. The methodology and tools are presented in deliverable 3.1, while this deliverable focuses on the results from the pilot region.

4.2 Description of the Norwegian Pilot Area and sources of maps

As the location of the potential sites are north of 60 degrees north, there are no digital maps of the pilot area at the site of the NASA Shutle Radar Topographic Mission. Instead it is made use of the map service of GisLink: http://www.gislink.no/gislink/

The municipalities of Midtre Gauldal and Holtålen were chosen for testing the methodologies and tools of the SMART project. Midtre Gauldal and Holtålen are located in the county of Sør-Trøndelag as illustrated in the below figures.

Figure 28 – Selected pilot region in the county of Sør-Trøndelag.

The black outline in represents the municipality of Midtre Gauldal and the red outline represents the municipality of Holtålen.

4.2.1 Political division, population and main economical activities

The area of Midtre Gauldal and Holtålen amounts to respectively 1861 km^2 and 1210 km^2. Furthermore, the estimated populations are about 6000 in Midtre Gauldal and 2100 in Holtålen.

Agriculture is one of the most important industries in the municipality of Midtre Gauldal and Holtålen, however it is of great importance for the farmers (landowners) to develop hydro power as a supplementary income in order to maintain a sustainable economical basis in these remote districts.

4.2.2 Hydropower exploitation

The main water course in this region is Gaula, which is a well known salmon river in Norway. Gaula with its 145 kilometres is the largest water course in Mid-Norway. In 1985 Gaula and all the rivers connected to Gaula were preserved. Still, there is possible to develop hydro power plants in the rivers connected to Gaula as long as some restrictions are met, in particular restrictions related to the amount of water utilized.

Also, the development of hydro power must not have a negative impact on the salmon. In addition, the intervention must not be in conflict with waterfalls which represent a nice scenery. In both cases one has to consider alternative locations of the intake and/or power station to avoid utilisation of water in such parts of the river.

In the fifties there were more than 40 small hydro power plants in Midtre Gauldal. Today there are 2 hydro power stations in Holtålen (About 5.8 MW installed capacity in total). and 7 hydro power stations in Midtre Gauldal (About 1 MW installed capacity in total). Most of the power stations were shut down in the late fifties and sixties because they were not regarded as profitable in comparison to the new larger installations which were developed in Norway to support the power demanding industry growing in Norway at this time. In addition, the larger installations were more stable compared to the smaller ones and did not cause power fluctuation on the electric grid (Many of the smaller hydro power plants were direct current installations).

4.2.3 Motivation for choosing this area

The chosen area represents a region with a power and energy deficiency and thus this is the main motivation for choosing this particular region as the pilot region. Also, hydro power in this area will be an important factor to increase the economic life in the districts and prevent depopulation.

Despite the fact that this region is preserved there are possibilities to develop hydro power when restrictions from the current authority is met. One should also bear in mind that there are many rivers or parts of rivers in these municipalities which are not controversial with regard to biological diversity, fish and landscape even if they are preserved. A sustainable development of hydro power with small interventions in the nature is an important and feasible mean to reduce the power deficiency in this region.

4.3 Description of the potential sites for SHP establishment in the municipality of Midtre Gauldal

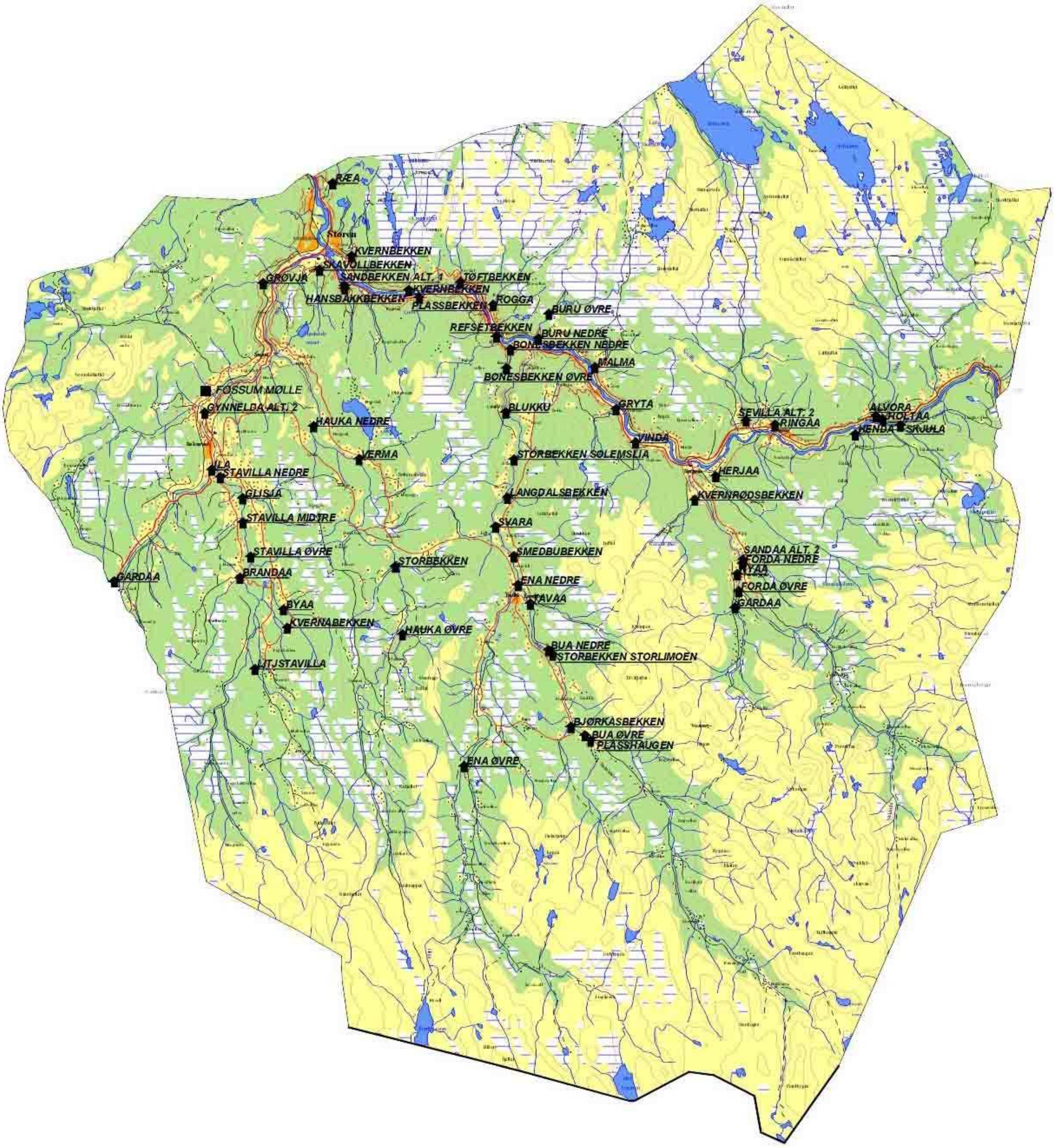


Figure 29 – Overview of the 61 potential sites for SHP development mapped in the municipality of Gauldal.

61 potential sites for SHP development were mapped in Gauldal as shown in the figure above. A preliminary estimation of potential and a brief investigation of the environmental concequences were

performed. The calculation methods for effect, energy production, pipe diameter and design pressure for pipe and pipe length presented, is in accordance with the methodology described in deliverable 3.1.

Considering small hydro power development it is important, as stated in S.M.A.R.T deliverable D3.1, to have a dialog with the landowners/ the locals and gain valuable site specific information. Possible consequences regarding for example heritage and the environment should be considered at an early stage. Each of the 61 cases of SHP implementation in Midtre Gauldal is preliminary investigated regarding power production and environmental issues following the guidelines of deliverable D3.1. The results for each power plant are presented in Appendix1.

An overview of the power potential of the 61 cases are presented in the table below.

Table 2 – The table below shows the results from analysis of possible SHP establishment in Midtre Gauldal.

Watercourse	Catchment area	Head	Flow Rate	Power output	Energy production
[–]	[km^2]	[m]	[m^3/s]	[kW]	[MWh/year]
Ræa	15.3	230	0.43	73.5	644.3
Kvernbekken north	9.8	190	0.23	29.4	257.6
Tildra	7.7	260	0.20	39.0	341.9
Tøftbekken	4.3	190	0.12	15.0	131.7
Rogga	20.0	145	0.55	58.9	515.9
Buru nedre	17.3	225	0.50	83.1	727.5
Buru over	16.5	45	0.48	14.8	129.5
Buru, liten	3.3	240	0.08	13.6	119.1
Malma	13.0	235	0.33	56.9	498.2
Sevilla	34.7	165	1.03	124.7	1092.3
Holta	35.5	130	1.03	98.5	862.6
Ringåa	2.3	202	0.05	6.9	60.1
Grøvja	4.0	240	0.11	18.5	161.7
Alvora	6.3	120	0.17	13.9	121.9
Gynnelda	28.4	175	0.74	95.1	832.8
Gardåa	13.0	35	0.23	5.4	47.6
Ila	130.6	95	2.29	159.7	1399.4
Branåa	11.8	85	0.19	11.2	97.7
Stavilla nedre	170.0	40	3.93	115.6	1012.4
Stavilla Middle	156.5	15	3.74	41.3	361.6
Stavilla over	150.0	20	3.62	53.2	466.0
Glisja	8.5	135	0.14	13.4	117.3
Kvernbekken sør	2.9	60	0.05	2.2	18.8
Byåa	7.3	15	0.15	1.5	13.4
Kvernabekken	3.3	20	0.07	0.9	8.1
Litjstavilla	19.5	15	0.54	5.5	48.4
Hauka nedre	161.9	150	5.34	628.9	5509.5
Hauka over	72.5	25	2.61	48.0	420.5
Verma	19.6	60	0.50	20.6	180.4
Storbekken	7.2	25	0.16	2.8	24.4
Bua nedre	179.9	10	5.07	37.3	327.0
Bua øvre	162.5	20	4.66	68.6	601.2

Blukku	9.0	190	0.22	28.2	246.9
Svara	7.8	90	0.19	11.5	100.9
Ena nedre	209.5	70	6.37	349.9	3064.9
Ena øvre	194.5	60	5.91	261.0	2286.5
Storbekken	3.5	190	0.07	9.1	80.0
Langdalsbekken	3.4	180	0.07	9.0	79.2
Smedbubekken	11.3	120	0.27	21.9	191.7
Tåvåa	17.6	100	0.46	33.7	294.9
Storbekken	5.1	75	0.13	6.6	58.0
Plasshaugbekken	21.3	50	0.54	18.5	162.1
Bjørkåsbekken	4.5	30	0.11	2.2	19.5
Skåvollbekken	4.3	115	0.09	7.5	65.4
Hansbakkbekken	6.3	165	0.14	16.3	143.2
Sandbekken	4.2	120	0.10	8.0	69.7
Plassbekken	6.0	255	0.14	24.1	210.8
Refsetbekken	5.8	190	0.13	17.0	149.2
Bonesbekken nedre	4.0	50	0.09	3.2	27.7
Bonesbekken øvre	3.5	145	0.08	8.4	73.3
Gryta	6.0	275	0.12	22.7	198.5
Vinda	9.3	105	0.19	13.4	117.5
Herjåa	41.5	105	1.09	84.3	738.6
Henda	24.0	230	0.54	91.4	800.5
Skjula	24.4	115	0.60	50.6	443.1
Forda nedre	266.0	50	7.45	274.0	2400.2
Forda øvre	222.2	125	6.67	653.9	5728.5
Kvernrødsbekken	13.5	110	0.33	25.1	219.8
Gardåa	8.7	105	0.23	16.3	142.9
Nyåa	37.7	180	1.01	133.3	1167.8
Sandåa	6.2	210	0.16	22.4	195.8
Fossum Mølle	144	14	3.28	33.8	296.3

4.4 Application of the SHP software tools to 9 rivers in Holtålen

In the municipal of Holtålen there are 84 potential sites for Small, Mini and Micro power plants. This survey covers 9 of these rivers to show the application of the SHP software tools for finding potential profitable SHP sites, described in S.M.A.R.T report D3.3.

The results for the 9 cases in the municipality of Holtålen, presented in this report:

Name of the Power Plant	Maximum flow rate [m³/s]	Net Head [m]	Energy production [MWh/year]	Power output [kW]
Bælingen	0,85	183	7,63	1330
Lea	1,36	98	6,54	1138
Nørdre Gisla	0,17	221	1,84	322
Renåa	0,15	188	1,34	234
Drøya	0,28	139	1,95	340
Benda	0,15	112	0,84	146
Storrena	0,18	138	1,23	214
Nørdre Finnsåa	0,11	194	1,00	175
Søndre Tverråa	0,19	187	1,71	298

Table 3 – Power Plants in the municipality of Holtålen

4.4.1 Results from the economical analysis of the power plants in the municipality of Holtålen

The SHP program tools are quick tools for preliminary analysis of potential sites for SHP construction. The SHP optimization program tool is suitable for finding the most profitable sites of SHP implementations. The following cases in Holtålen are analysed using this software tool.

List of priority	Rivers	Power output [kW]	Scope [NOK/kWh]	NPV [NOK]	PB [years]	IRR [%]
1	Bælingen	1 330	1,64	16 661 621	8	16,4
2	Lea	1 138	2,26	10 675 825	12	11,8
3	Nørdre Gisla	322	2,23	3 415 974	11	12,7
4	Drøya	340	3,27	1 873 940	18	8,3
5	Søndre Tverråa	298	3,3	1 549 809	19	8,2
6	Storrena	126	3,87	286 912	24	6,7
7	Benda	174	4,47	-132 587	>30	5,5
8	Nørdre Finnsåa	175	4,57	-224 655	>30	5,3
9	Renåa	234	4,59	-318 634	>30	4,6

Table 4 – Results from the analysis of the power plants in the municipality of Holtålen

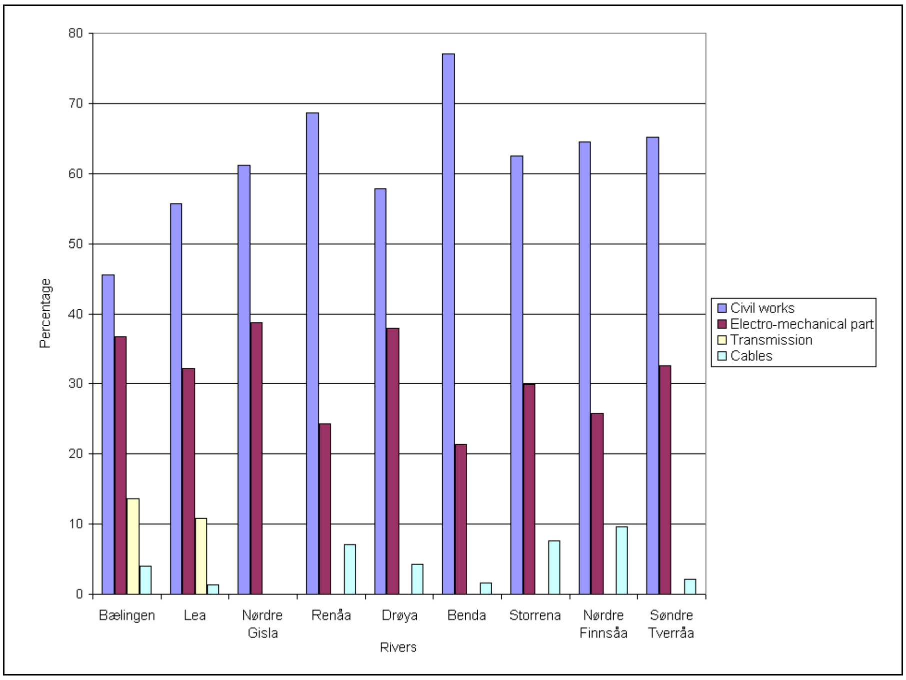


Figure 30 – Relative cost estimates for all power plants in the municipality of Holtålen

4.4.2 Conclusions

The Norwegian methodology and SHP programs described in S.M.A.R.T report D3.1, were successfully applied to the municipalities of Middle Gauldal and Holtålen. This preliminary analysis was resulting in several possible sites for SHP development for further investigation.

Building small hydropower plants requires substantial knowledge in different fields such as, hydrology, geology, topography, economy, environment and electro-mechanical engineering. It is indeed a team effort.

The main source of uncertainty in hydropower comes definitely from hydrology. Although hydropower helps to reduce greenhouse gas emissions, it is affected by hydrologic variations resulting from the climate change. This unpredictability can be decreased if the rivers are gauged for long periods. Nevertheless, the unreliability will persist for future scenarios.

The construction of hydropower plants depends on site specific characteristics. A field survey is indispensable in order to determine the exact location of the station and intake level. The initial layout based on a map might be completely modified after such a survey. It is very important to speak with the locals and especially to the landowners to learn more about the outdoor activities, environment, geology and fauna in the area as they are the ones who are the most familiar with these characteristics of the land.

The methodology described in report D3.1 can be used as a guide for landowners/ investors willing to develop small hydropower plants.

The SHP programs developed at NTNU provide powerful tools that simplify user tasks with a lot of data, iterations and repetitive actions. The SHP programs are user friendly and fast tools to calculate approximate costs of the main components of the SHP plant and helps to select the projects worthy of further investigation.

The Global view only gives a quick estimate on basis of the input data, and requires that the user for example knows how to optimise the pipe diameter as this is not done by this program.

The SHP Optimisation Program makes the most thorough analysis of the three Norwegian SHP program tools and is recommended for financial analysis. The nine rivers of the Norwegian pilot region were investigated mainly by the SHP Optimisation program.

The economic analysis helps to select the possibly feasible projects and to discard the sites not worthy to continue further with the hydropower planning investigation. It is based on average energy prices and interest rates, and also on statistical NVE cost functions. At present, these values are a good assumption, but their validity in the future is questionable. The financial crisis, green government political agendas and the exhaustion of fossil fuels reserves are all factors that will unpredictably affect hydropower development in one way or another.

SHP development can be important for the Norwegian pilot region. The landowners of the rivers which have been considered should continue with further investigations if they are interested in developing hydropower despite the fact that some rivers are not graded as economically feasible. The landowners can contribute with their own labour and materials which will reduce the cost and search for the best supplier in the market. A small hydropower plant is a long term investment and it will pay out in the end. With small scale hydropower and with efficiency improvements of existing installations it is possible to develop the remaining hydropower potential. Small scale hydropower plants are environmentally friendly and contribute to the economic life and countryside’s future settlement.

5 STRATEGIC ACTIONS – GREECE – NORTH-EASTERN ATTICA - RSA

5.1 Acquired experience with the SMART Mini-Idro application

The SMART project team of the Regional Secretariat of Attica worked on Asopos river basin simply because this is the only river with the greatest water quantities and major environmental problems. The regions strategy is to introduce actions and activities in support of the river's environmental flow. The digital tool used was SMART Mini-Idro. This is a friendly tool that can be used by any person working in the Water Resources Directorate or in the Environmental and Planning Directorate of any regional authority in Greece which is involved in the development of small hydropower plants. The employees who became involved in the testing phase recommended the preparation of Frequently Asked Questions (FAQ) document that will accompany the SMART Mini-Idro Guide. More importantly, the translation of the tool, the guide and its FAQ document would be of great assistance to Greek users in regional and municipal authorities.

5.2 Acquired experience with the Database and Public Cadastre in the web

This is the most important deliverable of the project SMART. It provides transparency in dealing with RES development projects in Greece. Its innovative character lies on its capability to provide information to local stakeholders, including investors, on small hydropower projects that could be taken into consideration immediately. The public cadastre will allow local stakeholders to know about available option for hydropower development in Asopos river. It also sets up a great best practice example of allowing the public to know about

5.3 Acquired experience with the Concessions

This remains an unresolved issue in Greece in general and in Attica in Particular. The Greek legislation has not resolved this problem for the time being. The management of the Greek water basins and the rules and procedures for concessions are now being examined by the Ministry of Environment, Energy and Climate Change.

5.4 Drafting and implementation of a small hydroelectric gross heads register

The SMART project team of the RSA faced numerous difficulties in order to obtain data for testing the SMART Mini-Idro tool in Northern Attica. The lack of readily available data for the Greek rivers and the small hydropower plants currently in operation is a major issue in Greece and has to be supported by European funds as well. The SMART project assessed this need.

5.5 Cooperation with other the regional authorities and stakeholders

The SMART project team shared the use of the digital tool SMART Mini-Idro with other regional authorities and local stakeholders and most of all investors. The tool was used by experts who are working on designing a small hydropower plant in Asopos river in Corinthia (west of Attica, in the region of Peloponnese.

The Asopos basins in Corinthia cover an area of 279 km2 and the mean altitude is 509 m. Meteorological and hydrological data for the last decades were used in order to estimate the hydrological balance of the basin. The considerations led to the following results: mean annual precipitation **182x106 m3**, mean annual infiltration and runoff **82.5x106 m3**. The coefficient of real evapotranspiration is **54.6%.** The most important hydrogeological unit is the conglomerates, carbonate and the alluvial deposits. Groundwater quantity problems have been recorded in the alluvial coastal aquifer, due to overexploitation. Hydrogeological interest presents the aquifer, which is hosted in conglomerates.

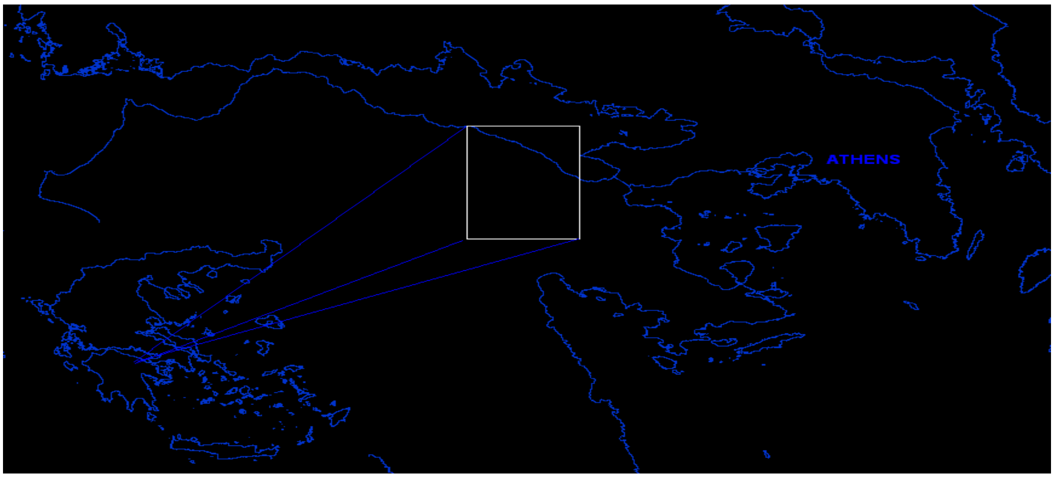


Figure 31 – Drawing with the entire Greek geographical area showing the pilot area incluse the Korinthos Asopos River

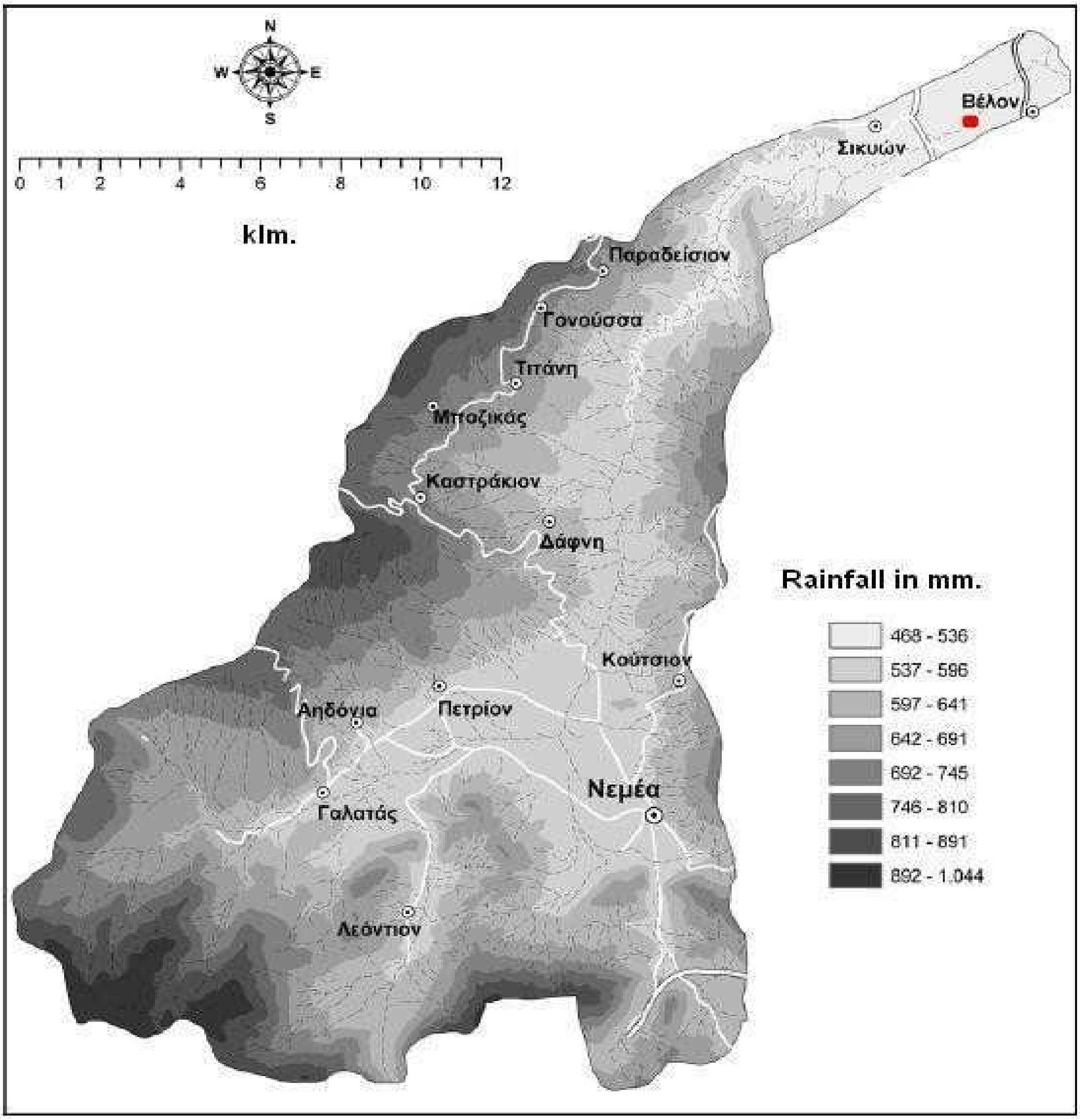


Figure 32 – Korinthos Asopos river basin with evidence in red, the proposal point and rainfall data in mm. (Taken from Antonakos A. & Voudouris K. & Koumantakis I., 1999)

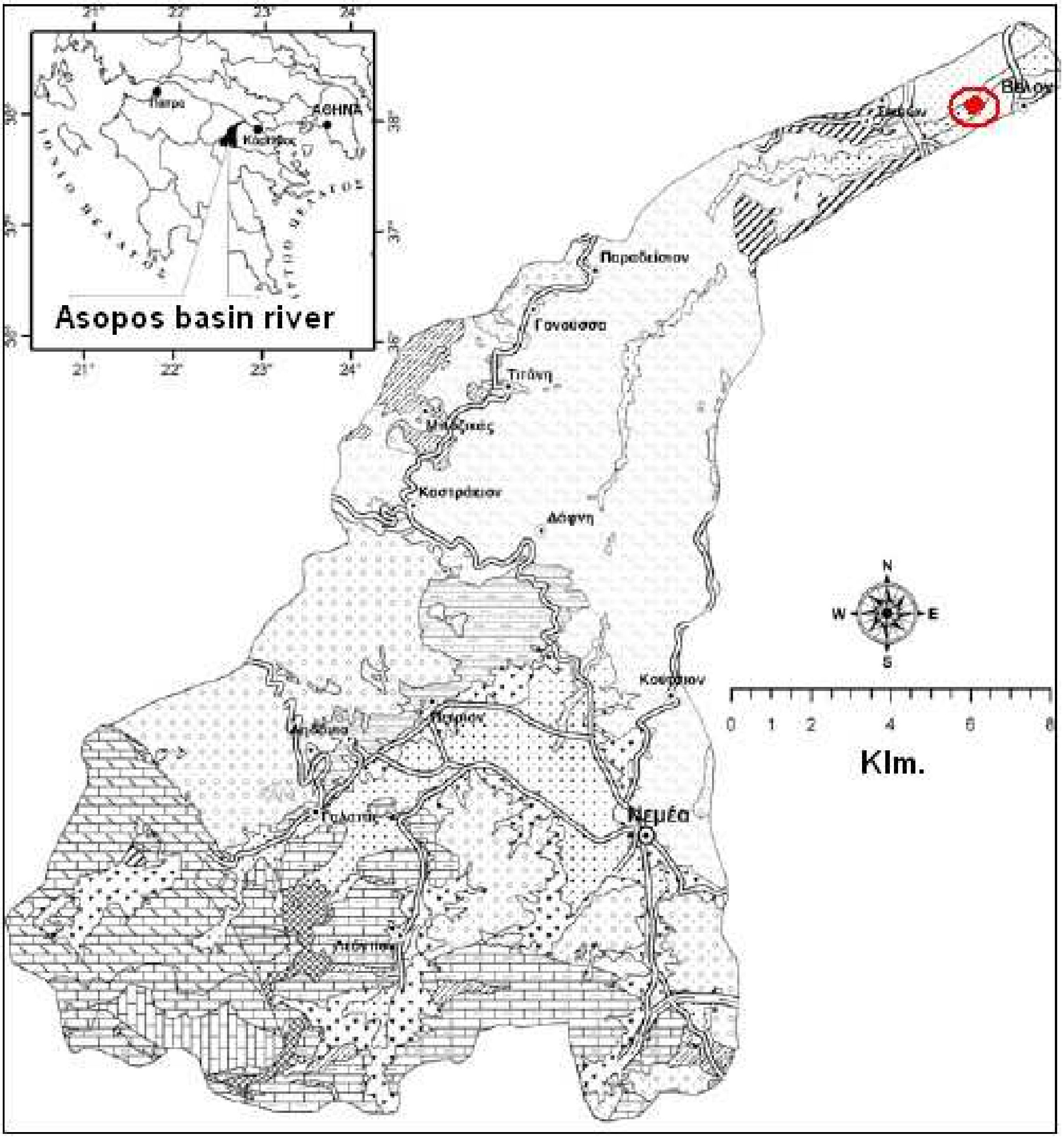


Figure 33 – Korinthos Asopos river basin with evidence the local litology (Taken from Antonakos A. & Voudouris K. & Koumantakis I., 1999)

Figure 34 – Aerial view of the Korinthos Asopos river and the propose point that corrisponde at the runoff station 01 of the georeferenced data

5.5.1 Political division, population and main economical activities

Respect the actual polulation of the area we suppose that the daily personal use of water during the winter is **180 lt.** and **280 lt.** during the summer time. Also we calculated the annual necesities about.

5.6 Application of the tool SMART Mini-Idro to selected potential hydropower sites

The SMART Mini-Idro tool was applied to the site n.1 in Asopos river, Corinthia, considering also the possibility to check other important points of the water basin describe in site 1

5.6.1 Site n.1 calculations

Medium monthly discharge in (m3/sec)													
Month	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual
m3/sec	0,8	1,6	2,1	2,1	2,4	2,4	2	1,8	1,4	1,1	0,7	0,6	1,4

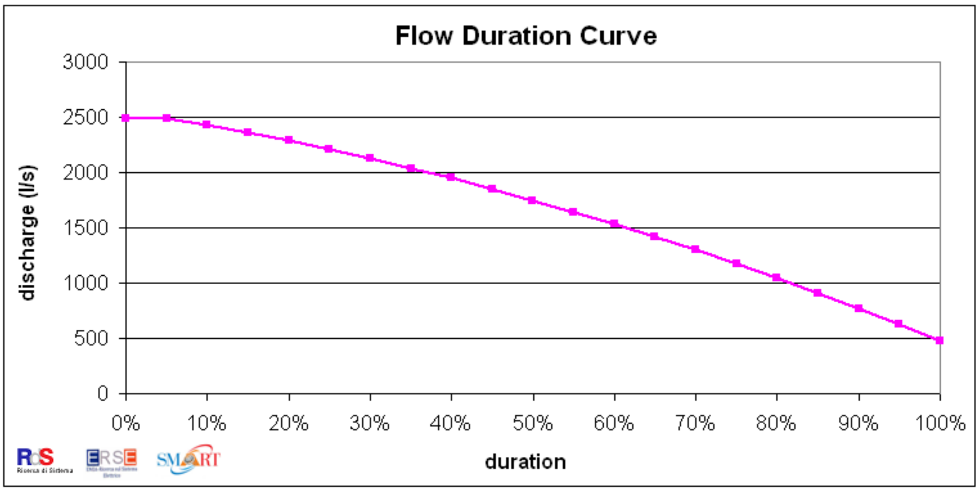
Table 5 – Discharge data in the Asopos river, Corinthia

The flow duration curve is presented in the figure below:

1.1 Flow Duration Curve calculation

Flow Duration Curve input: ○ Lombardia Regional curve (Italy) ◉ Direct input

duration (%)	discharge (l/s)
0%	2492.0
5%	2487.0
10%	2425.0
15%	2357.0
20%	2285.0
25%	2208.0
30%	2126.0
35%	2039.0
40%	1948.0
45%	1851.0
50%	1750.0
55%	1645.0
60%	1534.0
65%	1419.0
70%	1298.0
75%	1173.0
80%	1044.0
85%	909.0
90%	770.0
95%	626.0
100%	477.0
Qmean (l/s)	1660.1



1.2 Minimum Environmental Flow calculation (MIF)

MIF input: ○ italian low n. 7/02 ◉ Direct Input ○ percentage of Qmean

MIF [l/s] 166.0

Figure 35 – Site n1. Flow duration curve

The following figure shows the flow and power duration curves:

1.3 Net discharges calculation

duration(%)	Qgross(l/s)	MIF(l/s)	Qnet(l/s)
0%	2492.0	166.0	2326.0
5%	2487.0	166.0	2321.0
10%	2425.0	166.0	2259.0
15%	2357.0	166.0	2191.0
20%	2285.0	166.0	2119.0
25%	2208.0	166.0	2042.0
30%	2126.0	166.0	1960.0
35%	2039.0	166.0	1873.0
40%	1948.0	166.0	1782.0
45%	1851.0	166.0	1685.0
50%	1750.0	166.0	1584.0
55%	1645.0	166.0	1479.0
60%	1534.0	166.0	1368.0
65%	1419.0	166.0	1253.0
70%	1298.0	166.0	1132.0
75%	1173.0	166.0	1007.0
80%	1044.0	166.0	878.0
85%	909.0	166.0	743.0
90%	770.0	166.0	604.0
95%	626.0	166.0	460.0
100%	477.0	166.0	311.0

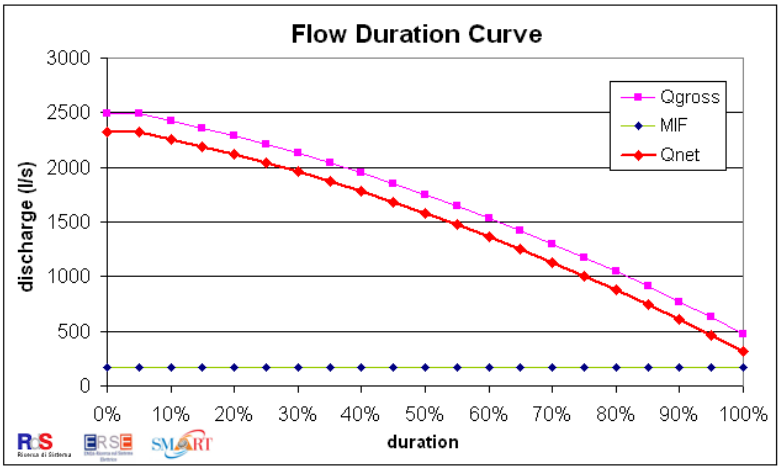


Figure 36 – Site n1. Flow and power duration curves

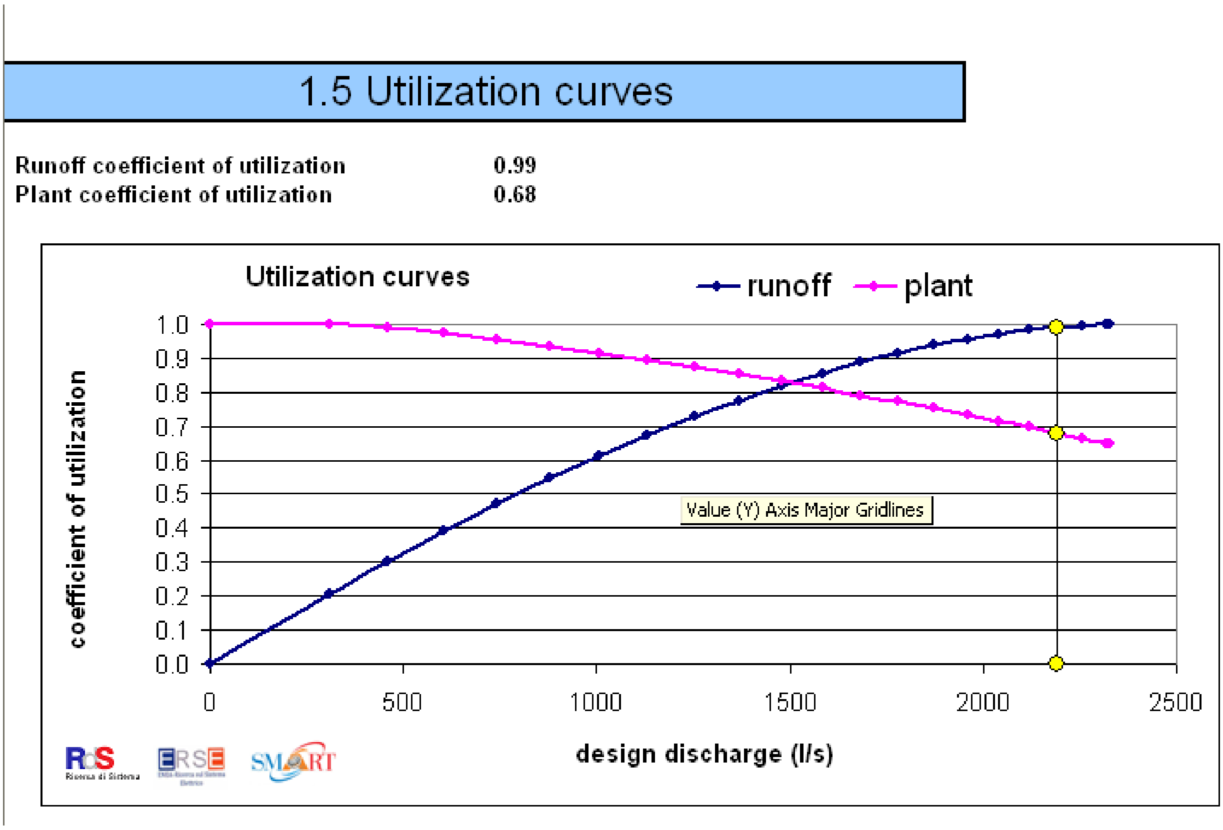


Figure 37 – Site n1. Construction of the model and necessary data

The necessary data to construct the model were the following:

- almost one point of mean annual discharge in the selected watercourse;
- the existing use points of the water.

Regarding the mean annual discharge value documented gauge station 1. The mean value of annual discharge was recovered from the station nearby collecting annual data, showing a 1,4 m^3/s. Errore: sorgente del riferimento non trovataXX shows the map indicating the discharge input position with coordinates

Latitude : (37°58'57.13")N - Longitude : (22°45'02.87")E - Elevation: 23 m.

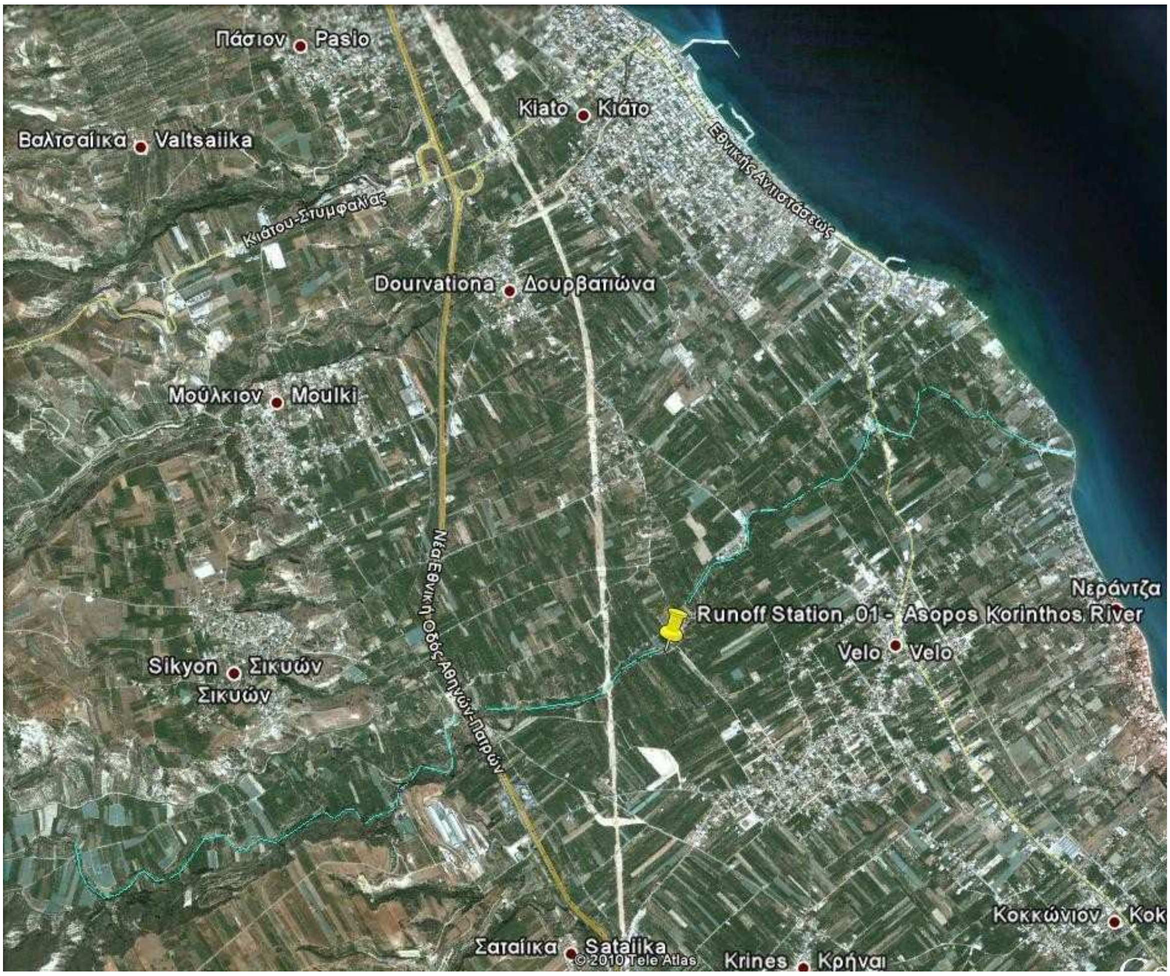


Figure 38 – The map indicates the point (in yellow color) proposed for installing a micro hydropower plant (shown in yellow), (394285, 4203418 -- alt.23m.)

The following water uses were considered in building Asopos –Corinthia model:

- Irrigation, the main use in the Asopos river basin countryside
- Future micro hydropower.
- Atrophic and coastal touristic activities.

The data regarding the water existing uses was provided by the NTUA (National Technical University of Athens and the Greek Institute of Geological and Mineral Exploration IGME.

5.6.2 Installable power and energy

2.2 Turbine selection

Turbine type Francis Turbine selection diagram

Curve correction	[%]	0%
Maximum efficiency	[-]	92%
Eff. alla Q di progetto	[-]	88%

Turbine Minimum Discharge:

Q/Qp 40% ⟶ **Q_{MIN} [m³/s] 0.88**

Q/Qp	Q (m³/s)	η
0%	0.00	0%
5%	0.11	0%
10%	0.22	8%
15%	0.33	22%
20%	0.44	34%
25%	0.55	44%
30%	0.66	54%
35%	0.77	62%
40%	0.88	70%
45%	0.99	76%
50%	1.10	81%
55%	1.21	85%
60%	1.31	88%
65%	1.42	90%
70%	1.53	91%
75%	1.64	92%
80%	1.75	92%
85%	1.86	92%
90%	1.97	91%
95%	2.08	90%
100%	2.19	88%

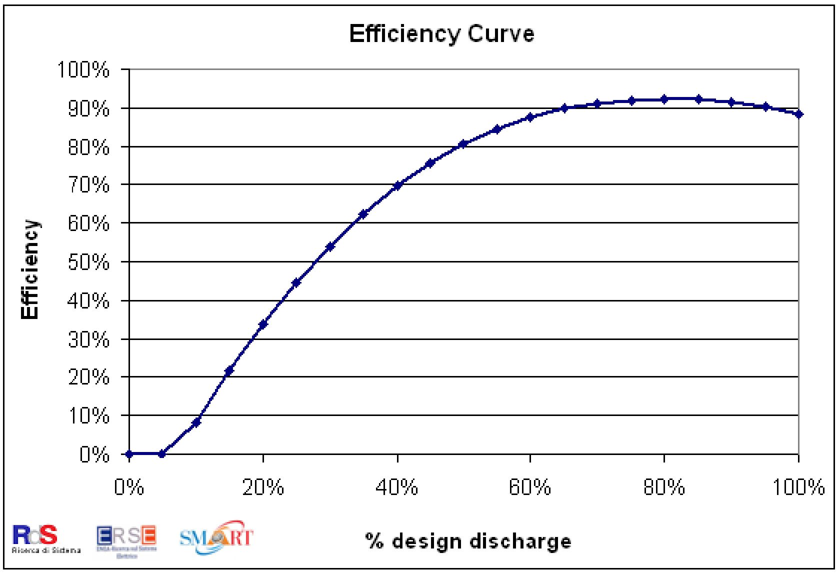


Figure 39 – Site n1. Turbine selection : Net head calculation and diagram with efficiency curve

5.6.3 *Cost Analysis*

4.1 Investment estimate

Type of calculation: (•) Synthetic estimate ( ) Formulas

Item	€
Civil works	3.000.000
Electromechanical dev. and	1.500.000
Administration and Planning	500.000
Miscellaneous	400.000
SUBTOTAL	5.400.000
VAT (% of subtotal)	23%
TOTAL (€)	#######

6.642.000

Total Plant cost	6.642.000	[€]
National contribution	40%	[%]
Capital Cost (€)	3.985.200	

Figure 40 – Site n1. Total in euro of Plant Capital cost %.

5.6.4 *Benefit from the energy selling*

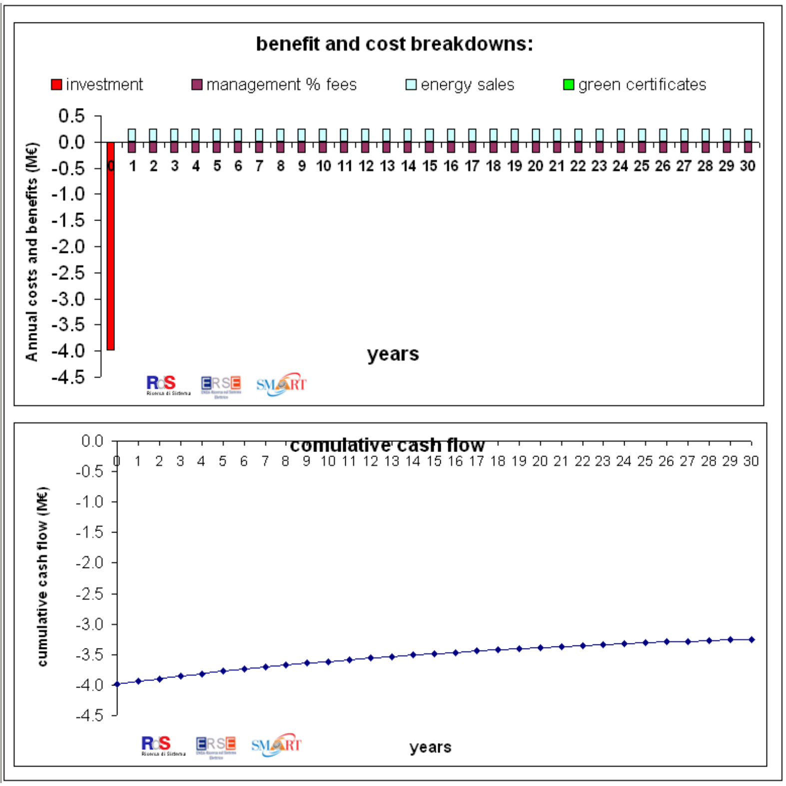


Figure 41 – Site n1. Diagram of negative cash flow in time of 30 years

5.6.5 Financial analysis

5. Financial Analysis

RdS Ricerca di Sistema · ERSE ENEA-Ricerca sul Sistema Elettrico · SMART

5.1 Parameters

Financial parameters	
discount rate	0.05
project life (years)	30

5.2 Annual costs

management & maintenance	3%	[% of the investment cost]
manag. & maint. costs	**199.260**	**[€/year]**
taxes & fees	12.57	[€/kW/year]
taxes & fees costs	**9.071**	[€/year]
Annual costs	**208.331**	**[€/year]**

5.3 Annual benefit

Energy price 0.07169 [€/kWh]

Green certificates SI — Green certificate price: 0.0003 [€/kWh] for the first 25 years

5.4 Financial analysis

Net present value (NPV)	-3.247.551	[€]
Updated performance index	-0.81	[-]
Equal benefit cost updated per	> 30	[years]
Pay Back Period	83.21	[years]
Benefit - costs rate	**0.55**	**[-]**

Figure 42 – Site n1. Financial Analysis of the project

5.6.6 Field visit to the hydropower potential sites

After a field visit in Asopos Corinthos river we indicate in the drawing below the water course between a few villages before arrives in the sea.

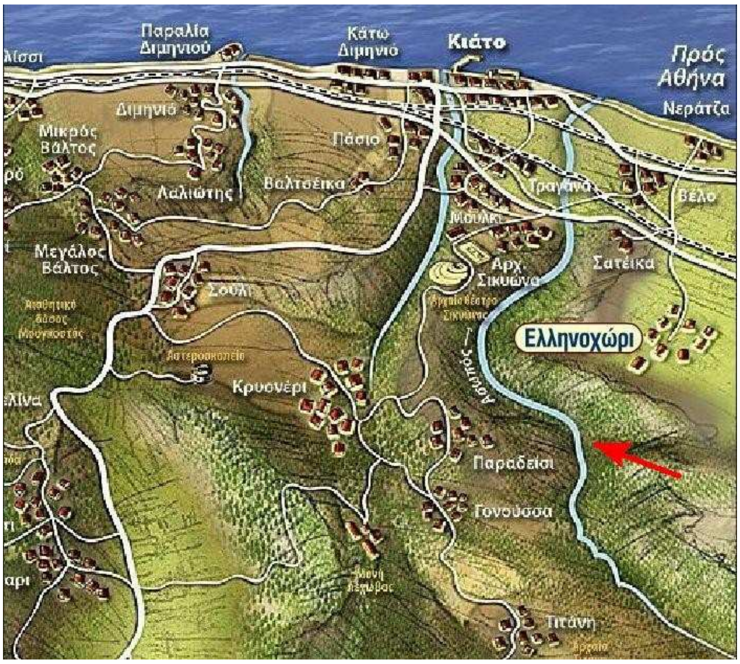


Figure 43 – Panoramic view of small villages around the pilot Asopos river indicated in red color

5.7 Conclusions

The strategy of promoting the use of renewable energy sources in general and small hydropower plants in particular has been facilitated with the application of SMART Mini-Idro. The application of the tool was indeed welcomed by national (i.e. hydropower experts in IGME) regional (i.e. Directorate for Water Resources Management) and local (Municipality of Asopos) and private investors (TERNA SA). In order to use SMART Mini-Idro in a study the hydropower potential of all Greek rivers and thus to provide useful information for a European public cadastre.

6 STRATEGIC ACTIONS – AUSTRIA – WALDVIERTEL LANDTHAYA COUNTY

6.1 Introduction

The northern region of Lower Austria is the "Waldviertel". north of the river Danube up to the Czech border. The sea level of this area is between 189 m and 1.056 m.

Figure 44 – Location of Waldviertel in Austria

The main rivers are the Thaya, Kamp and Krems Ysper and Weitenbach, which flows to the Austrian main river Danube. In the north of the region two smaller rivers Lainsitz and Braunbach flow toward the Moldau / Elbe.

Due to the very old geological structure the characteristic of the rivers are low decline of the rivers, special for Thaya and Kamp. There exists a lot of hydroelectric plants. The most plants have a low installed power most < 100 kW. During the last years some plants are closed or no investigations had be done. In particular after a big flood in 2002 some SHP had been destroyed and was not rebuild afterwards.

With the SMART-project should be given an input to reconstruct an build up new SHP. The tools, which have been designed during the project time will be helpful for a first draft for the hydropower potential of the rivers.

Basic date for existing barrier and the classification of the ecological situation according to the waterframeworkdirictive are pubished in the NGP (www.wisa.lebensministerium.at). In the map is also sections of the water bodies an the allocation to the big rivers shown.

Figure 45 – Ecologic classification of the river im Waldviertel (NGP: Nationaler Gewässerplan) green = without ecological risk, yellow = existing risk not clearly identified, orange = risk, to miss the EU water directive

As described in deliverable D4.1 the flow data of some measuring points are available for at www.noel.gv.at. The measuring is done by the government of country lower Austria and is also used as a food information system.

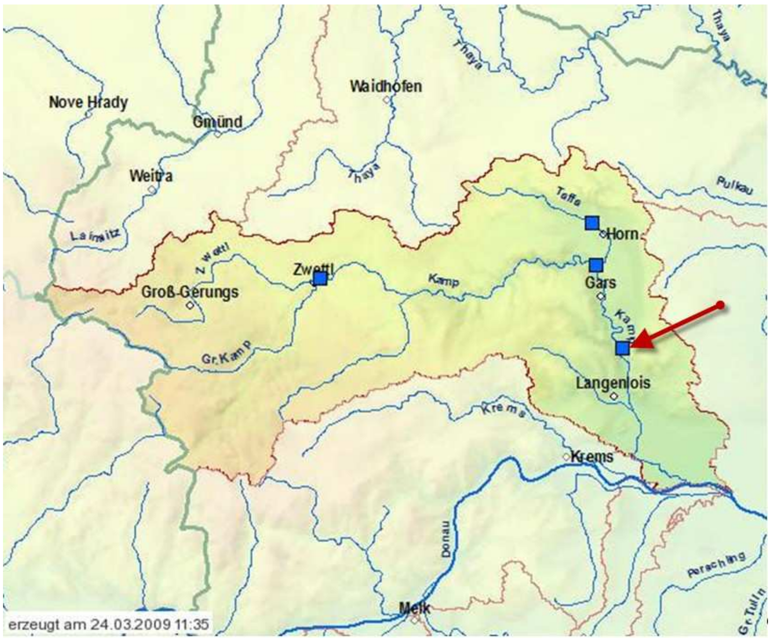


Figure 46 – Three measuring point of flow at the river Kamp

6.2 Experience with developed tools

In the pilot region of Waldviertel the longest rivers are the Thaya and the Kamp. The evaluation of possible places for SHPs will be identified in line with the SMART project.

RSE developed the tool VAPIDRO-ASTE aimed to analyse and optimize the hydropower potential of rivers. In detail for one site can be analyses done with the SMART Mini-Idro software.

Figure 47 – VAPIDRO-ASTE Software

The first step is to construct a digital elevation model. From international data-servers (eg. www.srtm.csi.cgiar.org) spatial data from the pilot region can be downloaded. The grid will be 90 x 90 m. The ASCII date must be converted to raster data with the geo-information-software e.g. Arcgis. On base of pysiographic data VAPIDRO-ASTE generates a river network. At least at one point in the river the flow must be given.

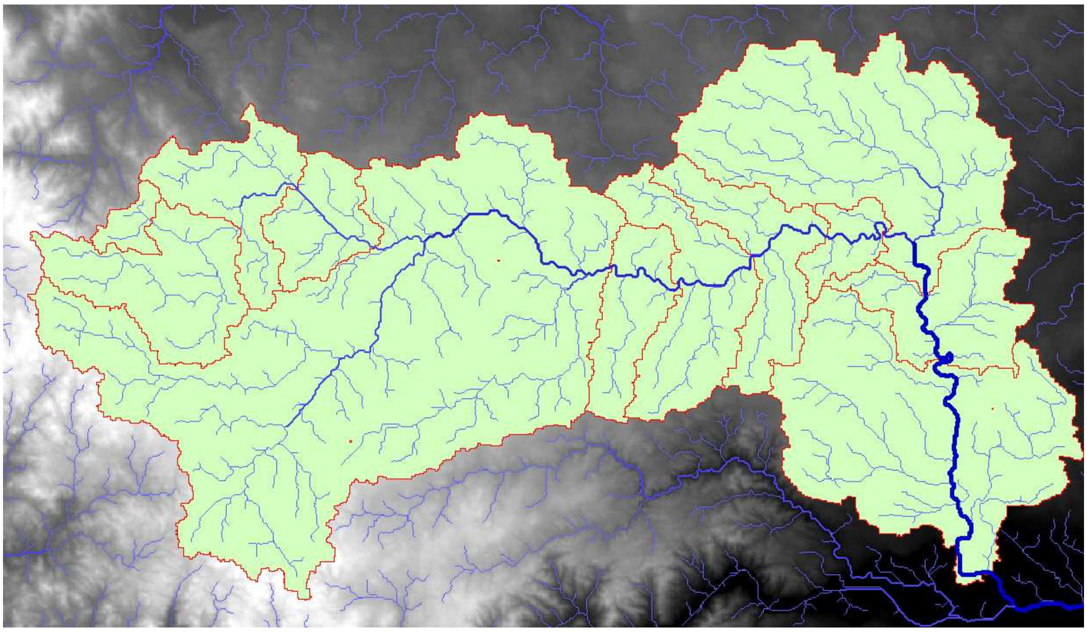


Figure 48 – River netork of Kamp and Zwettl with possible sites for SHP

In Figure 48 the river network is documented. For the small rivers, which discharge to the Kamp the basins are separated. For each basin the data e.g. area, highest and lowest point are available.

VAPIDRO-ASTE includes many helpful tools to evaluate the results, optimize the electricity production, calculate the investment cost and the benefit.

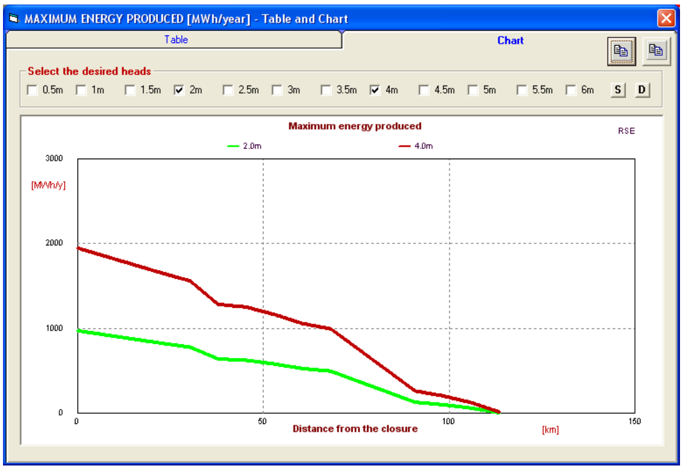


Figure 49 – Annual production for a head of 2 m and 4 m at any position of the analysed river calculated with VAPIDRO-ASTE

With the software an optimization was calculated. The locations of the 15 SHP with the highest benefit will be shown in the following figures.

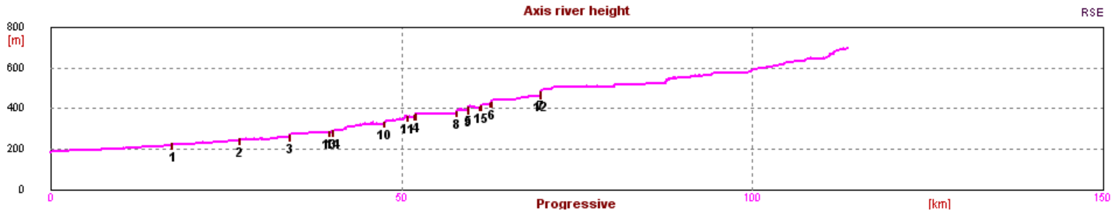


Figure 50 – Optimized locations

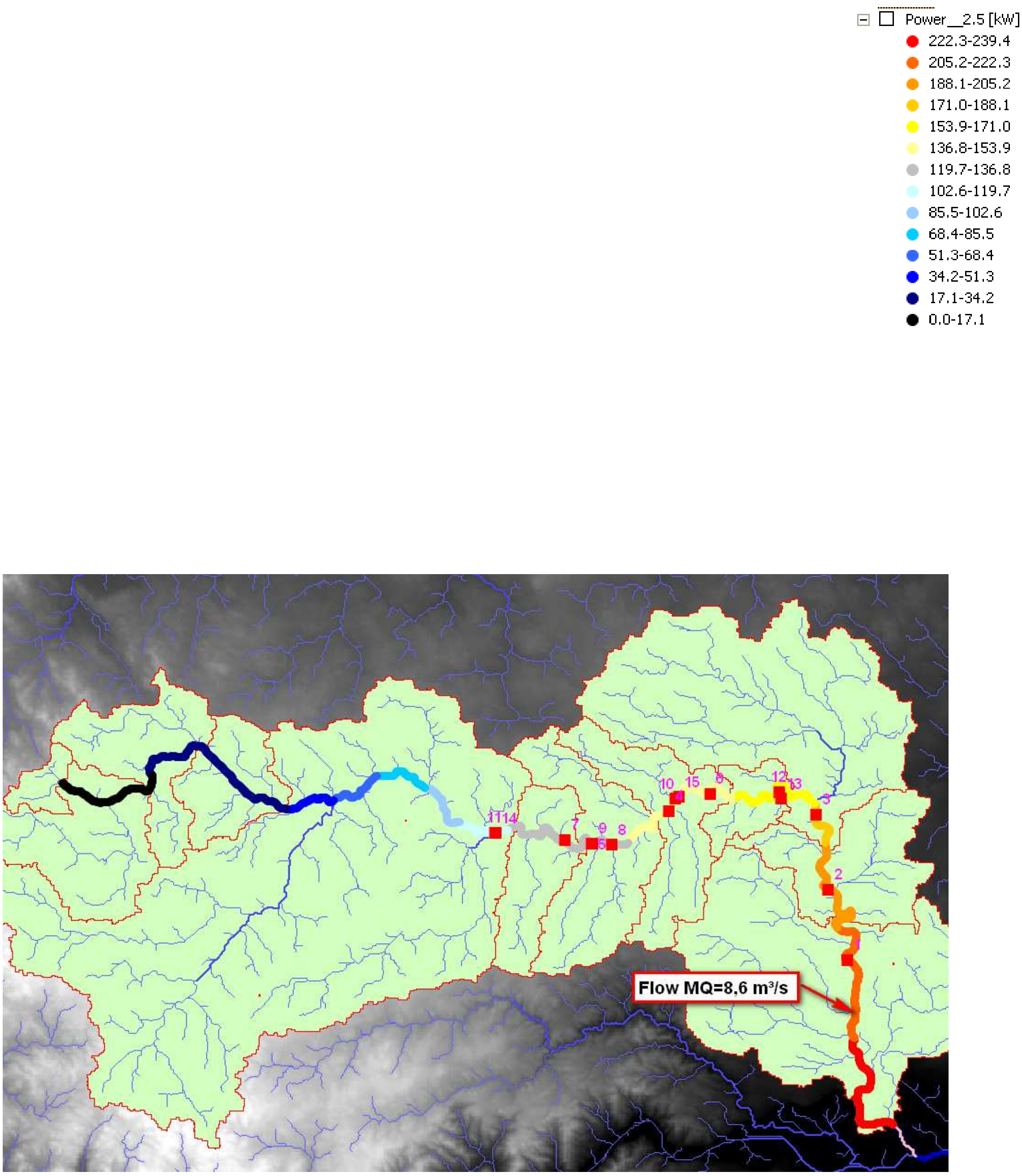


Figure 51 – Optimized locations for SHP with e.g. 2,5 m head Input point of the annual mean flow at Stiefern (between point 10 and 11 existing plant Ottenstein – Krumberg – Dobra)

Some results are correlated to existing plants but other are still free.