

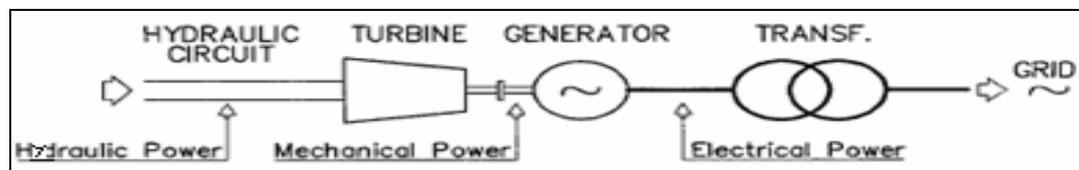
# Extended Abstract

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## Introduction

Large hydropower accounts for 79% of the total installed capacity of Renewable Energy Sources (RES) in Greece, according to data from the Greek Ministry of Development for the year 2005. The participation of small hydropower in renewable energy production that year was a mere 3%, in terms of installed capacity. During the last 5 years though, there has been an increasing investing interest in small hydropower which resulted in the authorization and development of a significant number of new projects.

Small hydroelectric schemes exploit the existing fall of water in natural or artificial waterways, for the production of mechanical energy and electricity, without regulating natural flow. Figure 1 illustrates the procedure of transforming dynamic energy of water into electricity through a hydropower scheme.



**Figure 1** Power conversion scheme in a small hydropower plant

The distinction between Small HydroPower Plants (SHPPs) and large ones is the limit of 10 MW of installed capacity, adopted by European Union as well as the Greek state. The purpose of this study is to record and analyze the current situation in the development of small hydropower in Greece, regarding the legislation and authorization framework, statistic figures of the progress of small hydro projects development and technical data .

A main target of the project is the creation of an Information System (IS), as a necessary tool for the storage, manipulation and distribution of the above data.

## **Legislation and authorization framework**

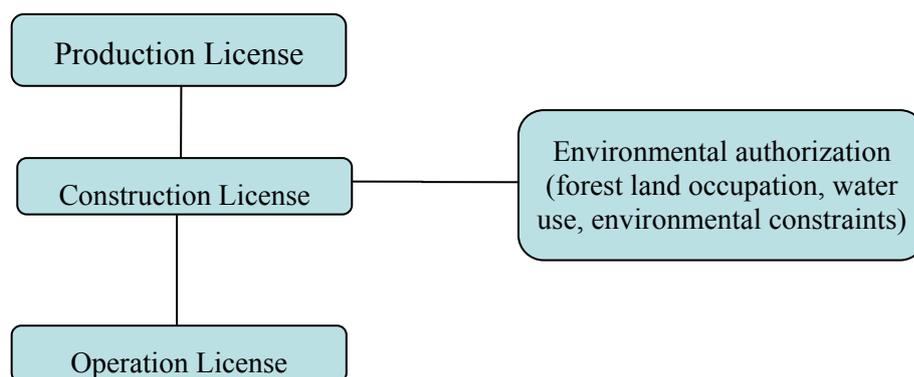
During the past decade legislation regarding the incorporation of SHPPs and RES in general in the Energy Grid (EG) has evolved significantly, having been adjusted to the directives of the European Community. European policy in favor of RES and the rationalization of energy management is imposed by the will to protect the environment (White Paper) in accordance to the commitments undertaken in Kyoto Protocol, as well as by the need to secure energy supply by reducing its dependence on energy imports (Green Paper).

In Greece, Law 2244/1994 was the beginning for the development of RES, setting the authorization framework and favorable prices for renewable energy. The Law instituted the concept of the independent energy producer, which was limited up to 5 MW capacity for small hydro units. Law 2773/1999 founded the Greek Energy Market, instituted the Regulatory Agency for Energy (RAE) and the Hellenic Transmission System Operator (HTSO S.A.), canceling the former energy monopoly of the Public Power Corporation (PPC).

Laws 2941/2001 and 3175/2003 solved various problems concerning project development, such as forest land occupation, connection to the grid and authorization procedures. The recent Law 3486/2006 applied Directive 2001/77 on Greek legislation, aiming to enhance the promotion of RES. The authorization and pricing framework were revised and the “Guarantees of origin” issuing system was instituted.

The Ministry of Development is responsible for planning the national energy strategy and issuing Production Licenses to independent producers, advised by RAE. RAE is responsible for studying and qualifying the applications, in accordance with the “Code for Electricity Production and Trade Licences”. The management of the procedures for issuing environmental authorization and Construction License is held by the local administration agencies, assisted by the local Forest Inspection Agencies. The Operation License is issued by the Minister of Development, with the advisory participation of HTSO and the Center for Renewable Energy Sources (CRES).

The precise environmental authorization procedures have been set by the Ministerial Decree 104247/2006. Figure 2 illustrates the typical authorization procedure for a MHHP in Greece.



**Figure 2** Typical authorization procedures for RES in Greece

## Current state of Small Hydropower in Greece

According to the Ministry of Development the contribution of RES in the domestic gross electricity consumption was 12.2% in 2005, nearly half of the respective target of 20.1% for the year 2010. The installed capacity of SHPPs was 72.4 MW, less than a quarter than the target of 364 MW set for the year 2010.

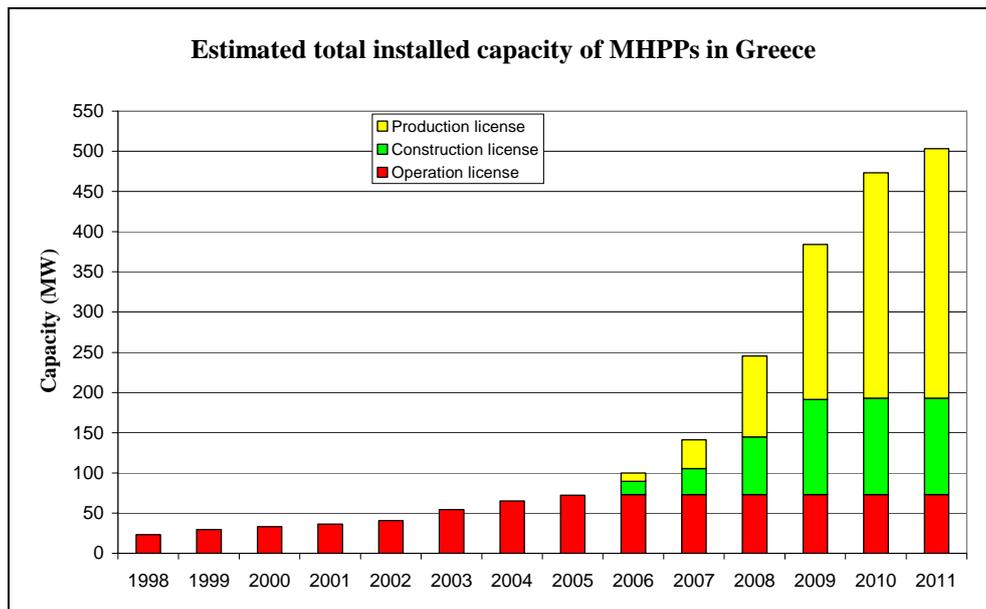
The data collected in order to study the extent of development of small hydropower in Greece consist of :

- File of the Operation Licenses granted, updated August 2006, including the projects' identification and capacity data, provided by RAE
- File of the Construction and Operation Licenses granted, updated July 2006, including data regarding the projects' identification, capacity and authorization dates, provided by the Greek Ministry of Development
- Coordinates of the SHPPs in the Greek Grid (1987) coordinate system
- Technical data about the intake, penstock and electromechanical equipment, for about 10% of the total set of small hydro projects

The comparison and cross-evaluation of the available data resulted in a final set of 250 projects, of 515 MW of total capacity. The data set consists of 48 plants in operation of 73.35 MW capacity, 53 plants under construction (119.92 MW) and 159 projects granted with Production License (309.95 MW).

According to the authorization dates the time needed for construction licensing administrative procedures was cut down from 22 months in 2003, to 12 months in

2004 and 10 months in 2005. This indicates the importance of legislation for small hydropower development, as well as the adjustment of the administrative services and the energy market to the new situation. Based on the maximum time allowed by legislation between authorization stages and the data available, a rather conservative projection of SHP installed capacity in the short future was made. The results, illustrated in Figure 3, indicate a boost in total SHP installed capacity to 245 MW in 2008 and 473 MW in 2010. This means that if only 73% of the licensed capacity is finally realized the target set for small hydropower in year 2010 can be achieved.



**Figure 3** MHPPs development history and future estimation in Greece

To the writer's opinion small hydropower can contribute further to the goal of increasing the RES share in the energy market. The total 430 MW of licensed capacity that can operate in the next five years is equivalent to Kremasta, one of the largest power plants in Greece (437.2 MW) and can increase the inland hydropower capacity by 14%.

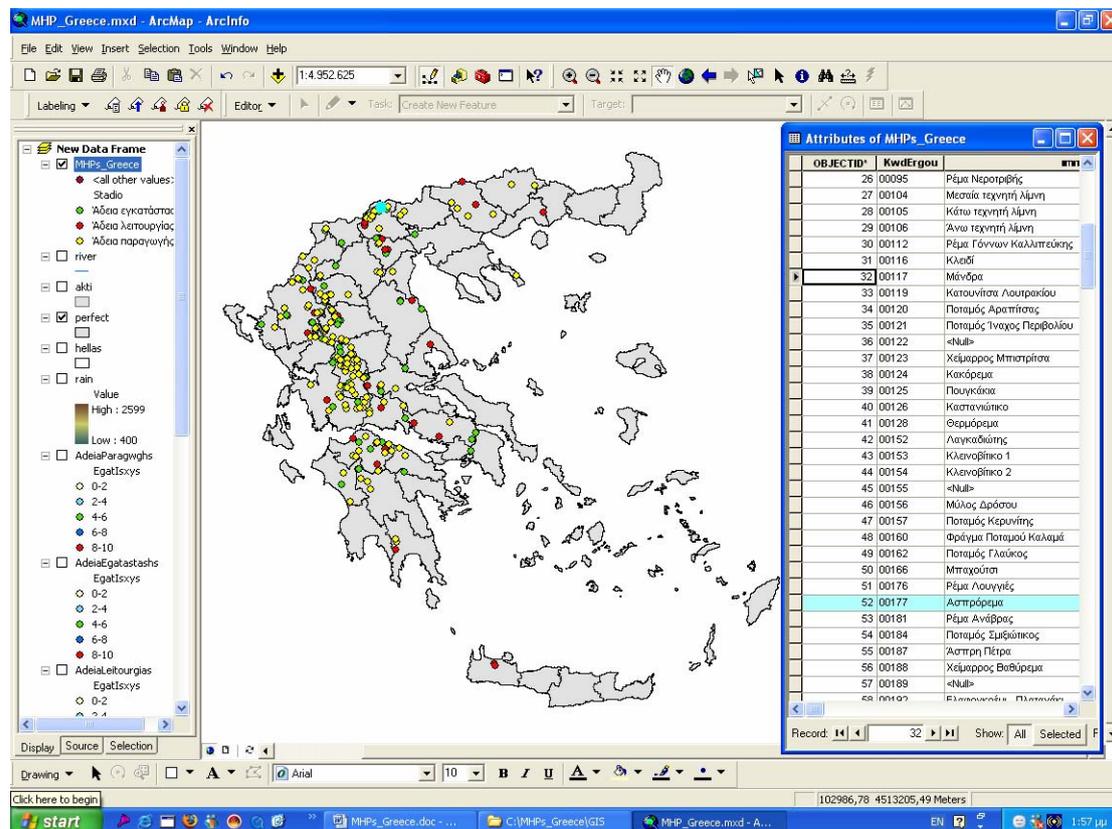
## The Information System

An Information System (IS) was created for the organization of the data collected for the operating and licensed projects as well as legislation documents and informatory material (technical guides, research studies etc). The IS is designed as a web site with links to the files, including informatory documents, a database created

with Microsoft Access software and a Geographic Information System created with ArcGIS 9 (ESRI) software.

The available data for the 250 projects was stored in the database, in 9 different *Tables* of a total 100 fields. The database was designed to facilitate the storage, management and access to the raw data, as well as to provide statistical information. 11 *Queries* were designed in order to extract data using different criteria (Operation License Code, location, capacity, design flow, gross head etc) and perform calculations. 13 *Forms* were designed in order to facilitate and refine the management and presentation of information. 14 *Reports* were designed in order to extract detail or summary data stored in *Tables* and *Queries*.

The GIS draws data from a geo-database created from the original database file. Geographic information of 231 SHPPs is stored in Layer “*MHPs\_Greece*” as coordinate data type. The file includes also geo-information about the coastline , the hydrographic network, altitude, rainfall and the administrative division of Greece. These data contained in shapefiles are also organized in different Layers.



**Figure 4** User interface of the GIS file for small hydropower in Greece

Through the Query property of Layers, the user can isolate and view projects, according to the authorization stage and installed capacity. Using the 14 Layers created in the GIS file, 7 thematic maps were designed and are included in this study. (Annex B). Figure 4 illustrates the user interface of the GIS file.

## **Conclusions**

Small hydropower in Greece constitutes at the moment a rapidly growing market, as one of the most flourishing branches of the construction sector. The projects to be completed in the next five years are a valuable aid in the race to catch up with the country's international commitments regarding electricity generated by RES. The conformation of the relevant legislation to the EC directives, resulted in a firm authorization framework which, combined with incentives such as subvention up to 45% of the installation and grid connection cost has drawn investors' attention. An increase by 300% of installed small hydropower capacity during the next five years is a reasonable estimation of the future development of SHPPs.

The IS created for this study provides an easy access to a variety of information regarding SHPPs, such as legislation and technical documents and access to the ongoing projects' data through the database and the GIS. Improvements can be made mainly to the direction of a more flexible and interactive structure. More critical is the need to sustain a reliable set of information, by updating the data on a regular basis.