UNIVERSITY OF PIRAEUS
Department of International & European Studies
MSc in Energy: Strategy, Law and Economics

University of Piraeus

Department of International & European Studies

Master of Science in

«Energy: Strategy, Law and Economics»

Thesis:

"Licensing, Technical and economical evaluation of Small Hydro Power Plants in Greece"

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Lamia, September 12th, 2021

The intellectual work fulfilled and submitted based on the delivered master thesis is exclusive property of mine personally. Appropriate credit has been given in this diploma thesis regarding any information and material included in it that have been derived from other sources. I am also fully aware that any misrepresentation in connection with this declaration may at any time result in immediate revocation of the degree title.

Dimitris Iakovakis

Water is the driving force of all nature

Leonardo da Vinci

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PREMISE

The current dissertation is about the techno - economical evaluation of a Small Hydroelectric Power Plant (< 10MW) in Greece.

It aims at identifying all steps of the licensing procedure of α Small Hydro Power Plant. Furthermore this thesis can be used as a model for the licensing and technical evaluation study of a Hydro Plant in Greece. Besides there is a gap of such bibliography in the country. The outcome of the study will provide also information that can be used for deciding to bid or not for the purchase of an SHPP and what a profitable price could be.

Furthermore, this thesis proves that the technical part of the operation of a hydro plant and more specifically its operational efficiency is not a priority for many Hydropower producers in the country.

The methodology of this study comprises of 4 parts:

- Licensing and operational frame of Small Hydro Plants in Europe
- Licensing analysis and evaluation of a Small Hydro Plant in Greece
- Technical analysis and evaluation after an onsite visit
- Economical Evaluation

Names and Assumptions

The following names, companies, licenses and locations are not real and shall be used indicatively for the purpose of the study. All photos have been taken by the studier from different hydro plants in Greece and are being used only to give a general view of the equipment and the sections of a typical small hydro plant.

It is responsibly declared that any identification with a real person, site or public service is completely coincidental and has been made without the slightest intention of insulting, causing any conflict of interest, raising issues and problems or posting

false information about individuals, companies or local authorities.

For the needs of the study, the following names and locations are going to be used in the context of this thesis.

Hydro plant name: Small Hydro Plant Lamprini (SHPP Lamprini)

River: ENIPEAS

Region: DOMOKOS

Plot of land: ZAMPARDIKI

Owner Company: LAMPRINI S.A.

Legal Representative: Mr. Papadopoulos Ioannis

Buying Company: AITHERAS S.A.

The same applies for all other names, local authorities, technical characteristics, locations, numbers, values and personal information mentioned in the core text of this dissertation.

Terms – Abbreviations

AVR – Automatic Voltage Regulator

COD – Commercial Operation Date

DAPEEP S.A. – Renewable Energy Sources Operator & Guarantees of Origin

EIA – Environmental Impact Assessment

ETA – Environmental Terms Approval

GRP – Glass Reinforced Plastic

HEDNO – Hellenic Electricity Distribution Network Operator

HNDGS – Hellenic National Defense General Staff

HSHA – Hellenic Small Hydropower Association

LAGIE or HEMO – Hellenic Electricity Market Operator has been renamed to DAPEEP S.A. (as described above)

LLIO – Local Land Improvement Organization

LV – Low Voltage

MV – Medium Voltage

PLC – Programmable Logic Controller

PPEs – Personal Protection Means

PPA – Power Purchase Agreement

RAE – Regulatory Authority for Energy

RES – Renewable Energy Sources

SCADA – Supervisory Control and Data Acquisition

SHPP – Small Hydro Power Plant (with nominal power capacity < 10MW)

UPS – Uninterruptible Power Supply

CHAPTER A - LICENSING AND OPERATIONAL FRAME OF SMALL HYDRO PLANTS IN EUROPE

1. Introduction

Hydroelectric power is the largest and probably the cheapest renewable energy source in the world, exempting biomass if considering also other energy applications. It is one of the most reliable (if the plant is installed in the proper location), exploitable and environmental friendly renewable energy alternative. However, the hydro-electric power may also have environmental impacts. The dams construction (especially speaking of large scale dams) is quite well known to cause significant ecological modifications, such as loss of biodiversity, deforestations in the surrounding areas and the roads, soil erosion and disruption of the free flow of the rivers. Additionally displacement of large numbers of humans was required in certain cases. Even so, hydroelectric power releases no direct greenhouse gas emissions and is a significant source of power in many parts of the world especially in terms of the base energy production. [1]

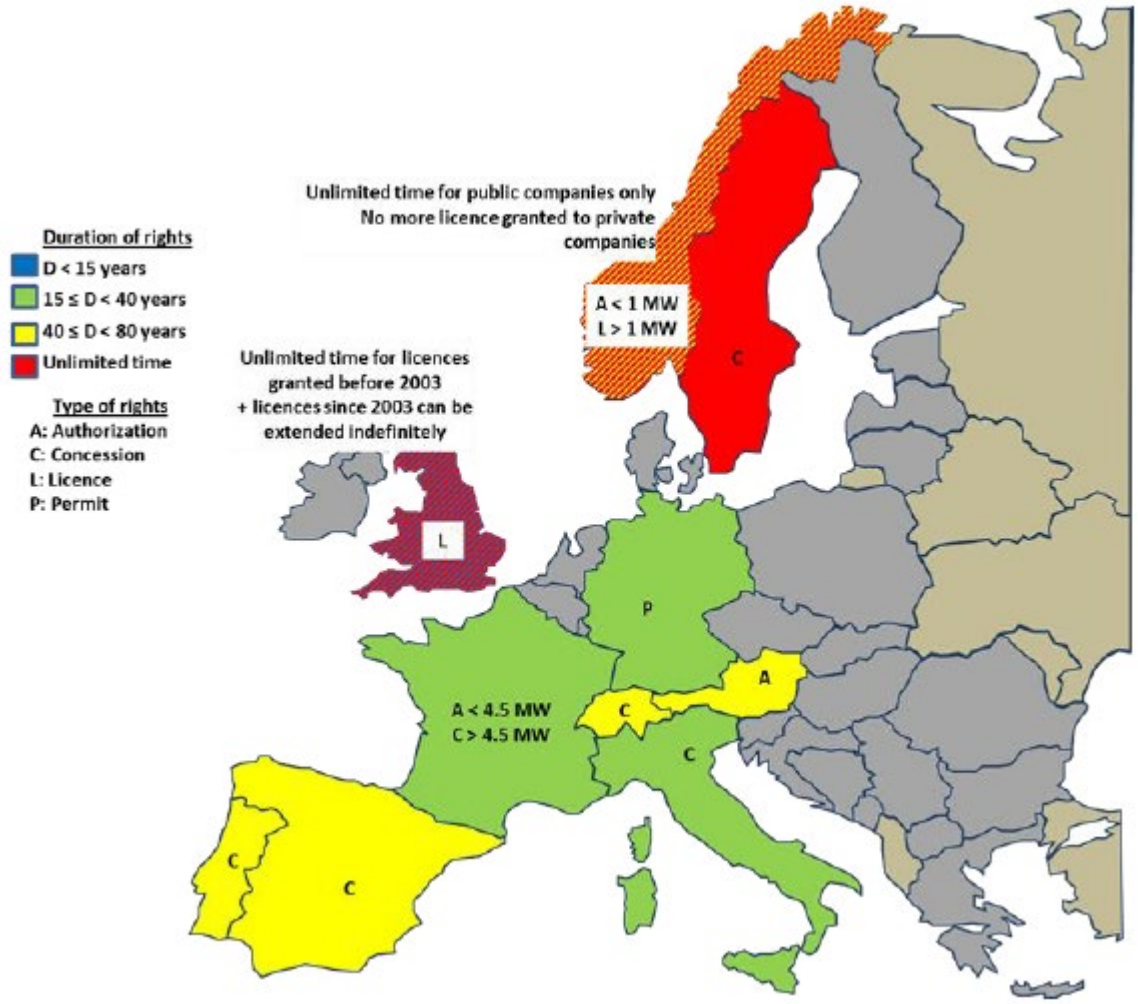
The institutional framework of hydropower is quite complex in general and it may involve both local and national authorities, because of the environmental impact of hydropower on watercourses, as mentioned above. The hydro power generator plays a detrimental role in the security of power supply and also in the climate change policy of each country.

2. Legislative Framework in European countries

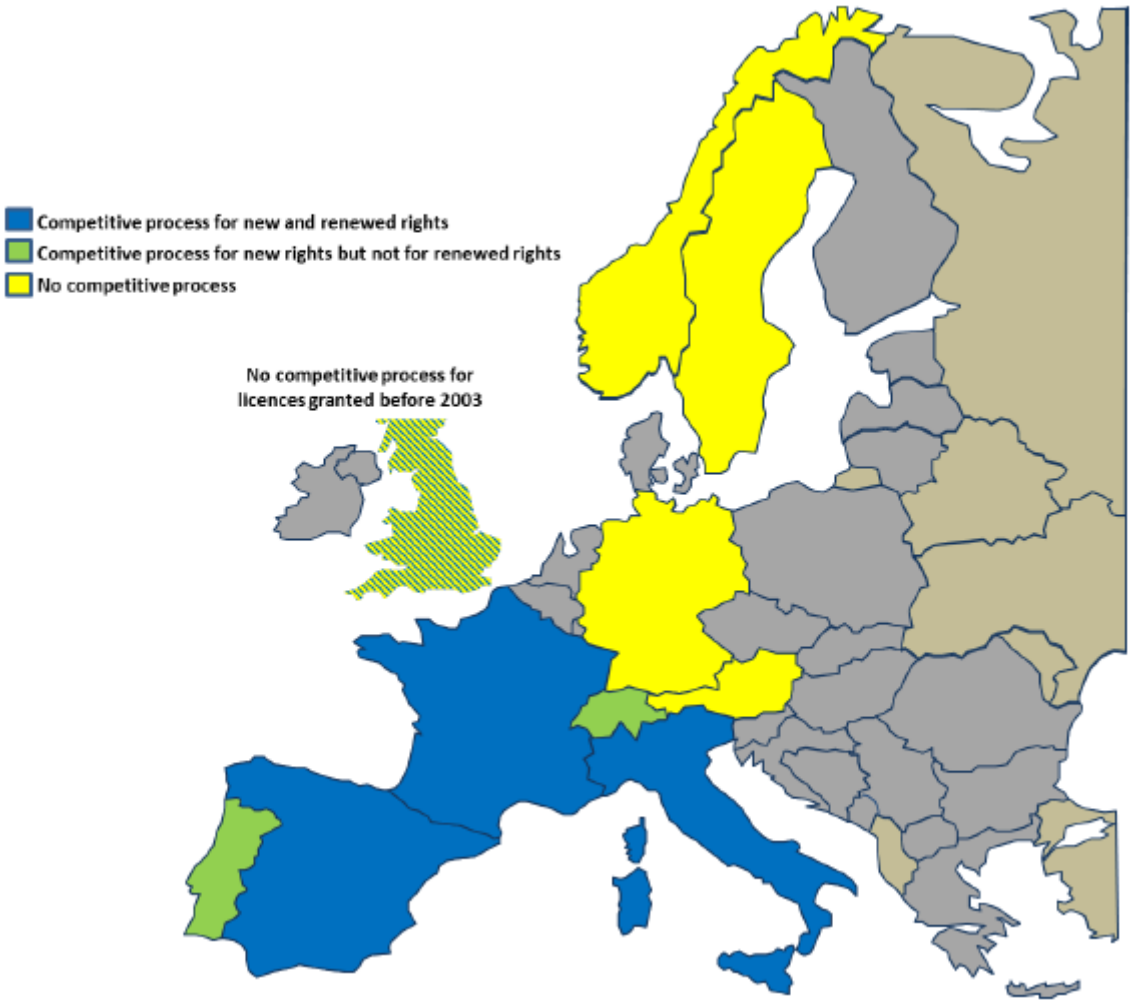
The licensing framework varies significantly between the different countries in Europe and the same applies for the validity duration of the permits of each SHPP.

In addition, the approach for granting concession rights in terms of new or renewed licenses is specifically defined in the European countries but with many differences among them.

A number of countries grant authorizations, others grant concessions for unlimited time and others directly negotiate concession licenses without a transparent competitive process for granting rights to use hydropower



Forms of rights to use hydropower granted for different durations [2]



Competitive process to grant rights to use hydropower [2]

Below follows a brief description of the legislative frame among European countries.

2.1. Austria

Austria relies significantly on hydropower, thanks to its high water potential. It has the peculiarity of being a federal country separated into 9 States, each with its own government and legislation regarding the use of water as well as environmental protection. Therefore, the frame of installing hydro power plants differs from one State to the other, according to both characteristics of local political situation and hydropower potential. However the general framework for hydropower access or use is not complex.

There is no concession system but a licensing process that provides long term licenses and is mostly organized at a local level, subjective to both State and federal legislations. These laws have been evolving to coincide with the prerequisites of the Water Framework Directive.

The Austrian Water Act is the main authority regarding water management. The Green Electricity Act provides the investment plans and framework for small (< 10 MW) and medium sized (< 20MW) hydropower plants. It deals also with purchasing obligations and guarantees of origin.

The EIA Act provides environmental planning instruments, development control plans, procedures and certifications.

The Federal Minister of Agriculture, Forestry, Environment and Water management is entitled with defining environmental protection rules and coordinating the local, State, and federal authorities.

The Austrian Reservoir Commission responds to the Federal Minister of Agriculture, Forestry, Environment and Water management and is entitled with supporting water authorities in terms of technical and safety issues about water rights procedures.

The local authorities are responsible for monitoring the procedures related with the use of water. There are three levels; the regional government and district authorities are responsible for water management and licensing for most hydropower facilities. The federal State authorities are responsible for authorizing small hydropower plants with a nominal capacity higher than 500 kW. The national authority is responsible for authorizing hydropower facilities on the Danube and cross border facilities. [2]

Characteristics			Description
Institutional framework	Authorities for granting rights of use		• Authorization by regional district authority for facilities <500 kW • National authority for facilities on Danube as well as cross-border facilities • Otherwise by federal States
	Types of hydropower right and granting procedures		• Applications for authorizations validated in compliance with environmental criteria only
Framework for granting right to use hydropower	Duration		• Maximum authorization duration: 90 years • On average between 25 and 75 years
	Competitive process	For new concessions	National legislation does not appear to provide for competitive procedure
		For concession renewals	National legislation does not appear to provide for competitive procedure
	EC infringement proceedings or equivalent		DG environment takes Austria to Court in April 2014 over failure to protect water quality on Schwarze Sulm river after infringement proceedings in 2013 on the grounds that the permit for the power plant is not in line with the requirements of the Water Framework Directive
Obligations of hydropower operators	Environmental obligations		• Mandatory EIA over 15 MW • Watercourse residual flow to be restore until 2027 in existing hydropower plants
	Investment obligations		National legislation does not appear to provide for investment obligations except environmental obligations
	Royalties		• Energy taxes • Local taxes • Mandatory participation to special funds • Licence fees directly negotiated with competent authorities
Small-hydro	Small hydro definition		< 2MW
	Support		• New or revitalised plants increasing efficiency by at least 15 % 3.23 – 10.55 c€/ kWh for 13 years, depending on revitalisation and the amount of electricity fed into the grid. • Obligations to purchase at market prices for hydropower < 10 MW • Alternative possibility of investment aid

Summary of Austrian hydropower framework [2]

2.2. Italy

Italy is lately in process of decreasing its reliance on thermal power generation and increasing the hydro power production.

In terms of institutional framework, there is a tendency to decentralize the national competencies to local authorities (Regions and Provinces) which now grant the concessions with a validity duration of 30 years.

The water policy framework is defined by the Water Consolidation Act. The Ministry of Economic Development is responsible for developing the national energy policy framework and for the coordination of activities related to the operations of national and regional planning operations of the energy sectors. The National Energy

Authority controls, regulates and monitors the electricity markets. The River Basin Authorities are entitled with protecting and designing any activities concerning water resources and river floods confrontation.

The licensing process for a small hydro project takes between 2 and 3 years and it requires no EIA submission. [2]

Characteristics			Description
Institutional framework	Authorities for granting rights of use		• Regions, and provinces if delegated
	Types of hydropower right and granting procedures		• Concessions
Framework for granting right to use hydropower	Duration		• 20 to 30 years for large scale hydro; 30 years for small hydro • Procedures from 3 to 7 years for small hydro
	Competitive process	For new concessions	Choice of competing applications • Based on economic offer • Increasing installed capacity • Other qualitative elements, e.g. ○ Equipped with an environmental management system, ○ Higher technical, financial and economic guarantees
		For concession renewals	Tender (awarding criteria) based on: • Economic offer • Increasing energy generated or installed capacity and • A plan for environmental improvement or restoration of the drainage basin concerned
	EC infringement proceedings or equivalent		• Closed (in 2007 – opened in 2002 and taken to EC court in 2005 by DG Internal Market and Services) after elimination of preference given to an outgoing concession- • Letter of formal notice sent in 2011 by DG Internal Market and Services because of the duration extensions possibly contrary to freedom of establishment. Procedure extended in 2013 as regards new 2012 provisions
Obligations of hydropower operators	Environmental obligations		• Watercourse residual flow defined by regions • EIA for hydropower plants > 40 MW and < 3 MW with a diversion capacity higher than 100 l/s in protected natural area (depending also on Regional obligations)
	Investment obligations		• Investment to increase plant capacity and efficiency as qualitative elements of response to call for tenders
	Royalties		Public rent to regions and Local Authorities
Small-hydro	Small hydro definition		< 3 MW
	Support		FiT or premiums (for 20, 25 or 30 years depending on size and type) (between 96 and 257 €/MWh depending on size and type) or green certificate system (for 25 years) for plants commissioned before 1 January 2013 (between 70 and 80 €/MWh in 2010-2013

Summary of Italian hydropower framework [2]

2.3. Norway

Numerous regulations and legal acts apply to all different stages of starting up, planning, designing and licensing of hydroelectric power projects. The most essential ones are the “Industrial Concession Act”, the “Watercourse Regulations Act” and the “Water Resources Act”.

In contrast to the licenses granted by the Water Resources Act, the Watercourse Regulation and the Industrial Concession Act define a revision of the specific licenses. The licenses granted before 1992 can be revised after the completion of 50 years of operation, while the newer ones can be granted a revision after 30 years of operation.

Additionally, the Planning and Building Act (PBA) applies to define a local character of the hydropower plants above a certain size level in terms of nominal power capacity, as well as additional installations and infrastructure.

The Energy Act regulates the technical installations related to hydroelectric power production, including also the connection to the voltage grid. In addition to the role played by the energy regulator NVE (Norwegian Water Resources and Energy Directorate) and other public authorities at the national level, both the municipalities and counties are provided with the mandate of managing overall objectives and principles for affected areas and the relevant land-use within their jurisdictions.

Regional and local assessments substantially influence the potential for existing and future hydropower projects. [3]

Characteristics			Description
Institutional framework	Authorities for granting rights of use		• Ministry of Petroleum and Energy • Ministry of Environment • The Norwegian Water Resources and Energy Directorate (NVE)
	Types of hydropower right and granting procedures		• Licences granted by King and government for waterfall purchase or long-term use (≥ 1 MW) after discussion by the Parliament (> 10 MW) or the Ministry (< 10 MW) and consideration by the energy regulator NVE • No licensing needed for micro (< 100 kW) and mini (<1 MW) power plants if the NVE agrees on limited environmental impact • Leasing to private companies
Framework for granting right to use hydropower	Duration		• Unlimited period of time for state-owned companies, municipalities and counties • Previously, up to 60 years for private companies, reversion at expiry. No more concession granted to private companies • Now possibility of leasing of public assets for 15 years only
	Competitive process	For new licences	National legislation does not appear to provide for competitive procedure
		For licence renewals	National legislation does not appear to provide for competitive procedure
	EC infringement proceedings or equivalent		International EFTA Court in Luxembourg ruling in 2007 that private or foreign companies granted a time-limited hydropower concession with obligation to revert installation to the State without compensation at concession expiry, whereas public companies benefited from time-unlimited concessions encroaching freedom of establishment and movement of capital guaranteed by the EEA Agreement. Nevertheless, this agreement lets the right to Norway legitimately pursue the objective of establishing a system of public ownership over these properties
Obligations of hydropower operators	Environmental obligations		• Mandatory EIA > 40 GWh • Protection of some river systems forbidding hydropower development in some watercourse, including from micro and mini power plants since 2005
	Investment obligations		• Make the necessary investments in order to ensure that these regulations are met
	Royalties		• Annual fees to the State: Minimum: 0.16 €/kW Maximum: 1.62 €/kW • Annual fees to counties and municipalities: Minimum: 0.16 €/kW Maximum: → 4.87 €/kW + Resource rent tax: 31% (for excess returns only)
Small-hydro	Small hydro definition		< 10 MW
	Support		Green certificates allocated for 15 years to RES in particular to measures to increase production at new and existing hydropower stations valued around 20 €/MWh in 2012-2013

Summary of Norwegian hydropower framework [2]

2.4. Portugal

The contribution of hydro power generation in Portugal is as high as 44% of the total energy production and the country intents to keep investing on the technology [4].

The new water concessions are granted with a validity duration up to 65 years, by

the federal government and the basin authorities, while expiring concessions must go through tender for their renewal.

The Water Act defines the institutional framework for the management of water. The authorities that are entitled with regulation and granting of water concessions are the Directorate General for Energy and Geology, which develops the energy policies; the Energy Services Regulatory Authority, which monitors the energy prices and the security of supply; and the Regional Basin Authorities (as mentioned above) that are responsible for granting hydropower concessions. [2]

Characteristics			Description
Institutional framework	Authorities for granting rights of use		• Directorate General for Energy and Geology (DGEG) • Regulatory Authority of Energy Services (ERSE) • Basin authorities (Administração da Região Hidrográfica -ARH)
	Types of hydropower right and granting procedures		Concessions for hydropower scheme via • Project application, or • Calls for bidding (auctions) conducted by the Government
Framework for granting right to use hydropower	Duration		Concession: up to 75 years Procedures from 3 to 11 years
	Competitive process	For new concessions	Case of application by a private investor • Request concession licence with ARH • ARH call for tender if project in the interest of the river • Opening to competing projects • Applicant selection based on highest bid for up-front payment with a possibility to outbid for the first applicant Case of ARH identifying need for hydropower installations: applicant selection based on highest bid for up-front payment with no priority to any applicant
		For concession renewals	National legislation does not appear to provide for competitive procedure
	EC infringement proceedings or equivalent		In-depth inquiry opened in 2013 (by DG Competition) into hydropower concessions to EDP to verify whether the price paid by the Portuguese electricity incumbent EDP in 2007 for the extension of its right to use public water resources for electricity generation was in line with EU state aid rules
Obligations of hydropower operators	Environmental obligations		• EIA • No regulation on watercourse residual flow but 5 to 10% of modular flow in average
	Investment obligations		For the protection of the environment (e.g. acceptable level of ecological and residual flows of watercourses)
	Royalties		Rate on water resources (The Taxa de recursos Hidricos -TRH)
Small-hydro	Small hydro definition		< 10 MW
	Support		9.5 c€/kWh for a maximum of 25 years

Summary of Portuguese hydropower framework [2]

2.5. Spain

The hydro power generation in Spain is quite low comparing to other European countries, as it barely reaches 8% of the total production.

According to the national legislation the hydropower generation facilities should have valid concessions or authorizations to operate. The legal hydropower framework is common at the national level, but Autonomous Communities have jurisdictions when river basins are located within their territory. Therefore, the management of water resources is described to be quite complex.

The Ministry of Energy is responsible for planning the electricity sector and it establishes capacity payments and feed-in tariffs.

The Directorate - General of Water which is a sub-direction of the Ministry of Agriculture, Food and the Environment is entitled to authorize hydropower installations when they affect more than one region. It also grants hydropower concessions with installed capacity greater than 5 MW.

The National Commission on Markets and Competition dictates the fair and transparent competition.

The Local Authorities and Autonomous Communities are responsible for further developing the regulation and legislation at a local level and for permitting HPPs with an installed capacity of less than 5 MW.

The River Basin Institutions under the Ministry of Agriculture, Food and the Environment are responsible for the intercommunity basins.

Finally, the Basin Authorities have the responsibility of water basins within their Autonomous Communities' borders. The Water Administrations are responsible for Basin Authorities. Both of them follow the same national legislation on water concessions. [2]

Characteristics			Description
Institutional framework	Authorities for granting rights of use		• Ministry of Energy for capacities > 5 MW • Local Authorities (*Comunidades Autonomas*), capacities < 5 MW • Basin Authorities
	Types of hydropower right and granting procedures		• Water concessions
Framework for granting right to use hydropower	Duration		• Up to 75 years + potential 10 years extension, if considerable investments have been made close to the expiry date of the concession • Procedure duration between 6 to 10 years
	Competitive process	For new concessions	• Competing projects on a vacant section of a river chosen from more rational use of water and a better environmental protection will be preferred • Partially or publicly-owned dams, the operation of the damn built to regulate the river flow, secure water supply during the dry summer months and avoid floods possibly used for hydropower generation whose operation may be offered to public tender through the Basin Authority
		For concession renewals	Expiring hydropower concessions that are reverted to the State may be subject to a call for tender procedure
	EC infringement proceedings or equivalent		Closed (in 2008 by DG Internal market and services – opened in 2003 with reasoned opinion sent in 2005) asking for a competitive procedure for the award of hydropower concessions in the Spanish legislation
Obligations of hydropower operators	Environmental obligations		• Mandatory EIA for plants located in environmentally sensitive areas • Preventing deterioration, protecting and enhancing the status of aquatic and terrestrial ecosystems and wetlands that are directly dependent on aquatic life regarding their water needs
	Investment obligations		• For the protection of the environment and watercourses • For functional state of installations at concession expiry (reversion to the State)
	Royalties		• Production tax (*Canon de producción*) • Regulation tax (*Canon de regulación*) • Taxes on water use (*Tarifa de Utilización del Agua*)
Small-hydro	Small hydro definition		< 5 MW
	Support		• Up to 2012: FIT for capacities < 50 MW • After 2012: no incentive mechanisms due to stringent tariff deficit measures

Summary of Spanish hydropower framework [2]

2.6. Greece

Approximately 11% of the electricity generation comes from hydropower in Greece [7]. The legal framework is quite complex and the process of authorizing a plant can take much longer than 5 years for a small hydro plant. A study case will be used in Chapter B in order to thoroughly examine this frame and all the licensing steps.

Especially in terms of the water concessions, there is a gap recently in the licensing process. All water concession licenses regarding any sort of water use (power

generation, irrigation, or even water supply) expire in 2022.

The HSHA, representing the vast majority of the small hydro power plants in Greece is claiming for the simplification of the licensing process and it seems that the legislation frame from RAE is moving to that direction already. [5]

3. Operational customs in European Countries

Countries with history in the hydro power generation, such as Norway, Austria, Switzerland, Germany and Italy have vastly invested on the operation of their hydro plants. The hydro power generation is not of course only a matter of multinational or statal companies but also of individual investments. However the culture of innovation and preventive maintenance is quite common among the majority of hydropower producers in Central and Northern Europe.

Enel Green Power which is the global leader in hydro power production has recently integrated all Enel's Large Hydro fleet in order to modernize and optimize their operation.

HYPER (Hydropower's Efficiency Revolution) has been a very ambitious project the last 5 years, aiming at improving the plants' operation in the name of digitalization and automation. Remarkable amounts of money have been invested on innovation and the pay-off has already started.

PreSAGHO (Predictive System and Analytics for Global Hydro Operation) aims at improving the preventive maintenance of the hydro plants in collaboration with major hydro manufacturers. Enel Green Power is also investing on unifying the scheduled maintenance among its fleet in order to increase their availability and efficiency. [6]

The hydro technology is very well known for being agelong. There are numerous hydro plants with their COD dated back to the last century. Their ability to produce efficiently vastly depends on proper maintenance and equipment upgrade.

In Greece the majority of the SHPPs are not being properly maintained and there is no collective efforts to that direction. Usually, each producer tries to upgrade his plant only based on his experience and his own efforts

CHAPTER B - LICENSING ANALYSIS AND EVALUATION OF A SMALL HYDRO PLANT IN GREECE

1. Introduction

In Chapter B the licensing procedure for a small hydro plant in Greece (case study) will be examined, by checking and evaluating step by step all its permitting documents. Besides there is a gap of how a thorough evaluation should be performed.

The examination begins with the recording of all essential technical and operational elements of each license that has been issued in chronological order. Afterwards, the SHPP's licensed characteristics are being cross-checked with the installed ones and the Chapter B ends with the conclusions deriving from this study.

The evaluation of the SHPP's licenses is based on the formal licensing procedure, as indicated by the current law in force N.3468/27-06-2006 regarding the electrical energy production from Renewable Energy Sources (RES) and Coproduction of Electricity and Heating of High Efficiency [8].

2. Licenses in Brief

Below follows a brief description of the most essential licenses of the SHPP according to the applicable laws.

2.1. Production License

Initial Production license

SHPP Production License issuance with the following characteristics:

Nominal Power: 0,85 MW

Annual Energy Production: 1,9 GWh

Position: Zampardiki plot, Region of Domokos next to Enipeas river, Prefecture of Fthiotida, Circumference of Sterea Ellada

Ownership: The OWNER has its headquarters at Domokos and his legal representative is Mr. Papadopoulos Ioannis. The shareholders are by 70% Mr. Kapsis Ioannis and the Company Hydro Thinking S.A. by 30% with Chief Executive Officer Mr. Georgiou Nikolaos.

Technical Characteristics:

- Intake from installed irrigation channel at an altitude of +130 m
- Penstock length 1.180 m (530 m – Φ 1.400 GRP, 520 m – Φ 1.300 GRP, 130 m – Φ 1.300 steel)
- Power house surface: 120 m^2
- Power house altitude: + 87,8 m
- Turbine: Francis 860 KW, 750 rpm, 2.200 lt/s, net head: 40 m
- Alternator: Synchronous 3 phase, 950 kVA
- Transformer: 1000 kVA, 0,4/20 kV

Modifications: Any new construction or modification of the above basic technical characteristics of the SHPP, or operational interruption, must be performed only after written notification of the Ministry of Development and of RAE

Production license duration: 25 years (until 12/06/2031) and may be extended according to the Production Licenses Regulation

Renewal of Production License: An application for the renewal of the production license can be submitted after the year 2023 (which corresponds to the 2/3 of the total duration of the aforementioned license.

After receiving the Operating License, the holder of the Production License must, within the first two months of each calendar year, inform the competent service of the Ministry of Development as well as RAE on the following data relating to the previous year:

I. The Annual Energy Production and the Maximum Power Production of the Hydro Power Station recorded during this period.
II. The annual percentage of unavailability of the SHPP and the reasons for

which it is due.

III. Any operational problems of the Hydro Power Station due to its faults and malfunctions or due to the Medium Voltage Grid

2.2. Environment

Concession of land for the Installation of the SHPP (XXXX/01-09-2005)

Positive opinion from the Directorate of Sterea Ellada - Fthiotida for the concession of the plot of land no. 41 next to the bank of the river Enipeas, with a surface of 5,000 m2 for the installation of the SHPP Lamprini

Concession of land for the Installation of the SHPP (XXXXXXX/01-10-2005)

Concession by the Department of Urban Planning & Environment / Department of Environment of the plot of land no. 41, next to the bank of the river Enipeas, with an area of 5,000 m^2 to create a MUSE..

The plot of land is located:

- Out of Residential Control Zone
- Outside the limits of General Urban Planning
- more than 1,500 m away from the nearest settlements of Palamas and Goura

Therefore there is no urban barrier to prohibit the installation

Concession of land for the Installation of the SHPP (XXXX/01-10-2005)

Positive opinion from the Ephorate of Prehistoric & Classical Antiquities for the concession of the plot of land no. 41, next to the bank of the river Enipeas, with a surface of 5,000 m^2 for the creation of a SHPP

SHPP Installation Points of View (XXXXXXX/03-01-2006)

Positive opinion from the Directorate of Forests of Domokos for the installation of the SHPP on the plot of land no. 41, with a surface of 5,000 m^2.

Environmental Impact Study 01/2006

SHPP Characteristics: Nominal Power: 0,85 MW / Average annual production: 2.165.000 kWh / diversion length: 998 m / penstock length: 983 m excavated for most of the adjacent dirt rural road / water reservoir: no / staff number: 1 person.

Coordinates: Water Intake X= XXX.XXX, Y= Y.YYY.YYY / Power House: X= XXX.XXX, Y= Y.YYY.YYY

Water Turbine: Francis horizontal shaft / 2,2 m^3/s / net head 40 m / 0,85 MW / 750 rpm / shaft height: +90,5 m / Altitude of lowest water level: +87,8 m

Generator: Synchronous 3 phase / 950 KVA / 0,4 kV / 50 Hz / cosφ 0,8 / 750 rpm / protection IP23

Transformer: Oil / 1000 kVA / 0,4/20 kV / 50 Hz / H/N Bucholz / YnD1

Other information: The installation site of the SHPP is not located within a protected area

Operation: The SHPP will utilize during the period October to March a part of the water flow of the Enipea springs that will be conducted through the irrigation canal of the Municipality of Domokos. The water after its use for electric power generation will be re-supplied to the river Enipeas.

Decision of Environmental Terms Approval (ETA XXXX/01-07-2006)

Environmental Terms Approval for the operation of the SHPP Lamprini (Enipeas Springs) of the owner company Lamprini S.A. from the Department of Environmental & Spatial Planning

Technical Characteristics:

- Nominal Power 0,85 MW with average annual energy production: 2.103.500 kWh
- Water intake from an existing irrigation canal at an altitude of + 130 m
- Supply penstock of length 1.180 m (530 m – Φ 1.400 GRP, 520 m – Φ 1.300 GRP, 130 m – Φ 1.300 steel)

- Power house surface: 120 m^2 approximately and installation site: 5.000 m^2 which belongs to the plot of land no. 41 of common use that will be granted to the project implemented society
- Altitude of producing unit: + 87,8 m
- Water turbine: Francis 860 KW, 750 rpm, 2.200 lt/s, net head: 40 m
- Generator: synchronous 3 phase, 950 kVA
- Transformer: 1000 kVA, 0,4/20 kV
- Other auxiliary installations

Operation: The SHPP will utilize 4/5 of the water supply that runs through the irrigation channel of the area and will operate throughout the non-irrigation period (October - March). The diversion of the water will take place after the approval of the competent Local Land Improvement Organization (LLIO)

The installation of a fire extinguishing system approved by the relevant Fire Service is required

Landscaping of the area and building formation is mandatory in order both to be harmonized with the natural environment. Tree planting must also take place at the perimeter of the installation site of the power house.

After the permanent shut down of the plant, the owner company must remove the entire installation and restore the space to its previous form.

Beneficiary: Lamprini S.A. based at Domokos, legally represented by Mr. Papadopoulos Ioannis

Decision of Environmental Terms Approval duration: until 01/07/2011

Issuance of unified water usage license (XXXX/01-08-2006)

The Department of Water Resources Management grants a unified license of water usage and execution of a project of utilization of water resources and installation of a SHPP of 0.85 MW at the plot of land Zampardiki, Region of Domokos next to Enipeas river, Prefecture of Fthiotida, Circumference of Sterea Ellada, legally represented by Mr. Papadopoulos Ioannis

Technical Characteristics:

- Water intake altitude +130 m from existing irrigation channel of competence of the LLIO, with coordinates: X= XXX.XXX, Y= Y.YYY.YYY
- Supply penstock length 1.180 m (530 m – Φ 1.400 GRP, 520 m – Φ 1.300 GRP, 130 m – Φ 1.300 steel) excavated along most of the adjacent dirt rural road
- Production station with a surface of 120 m^2 in an installation field of 5,000 m^2 which belongs to the plot of land no. 41 (next to the bank of the river Enipeas), of public forest land with coordinates X = XXX.XXX and Y = Y.YYY.YYY
- Production unit altitude: + 87,8 m
- Water Turbine: Francis 860 KW, 750 rpm, 2.200 lt/s, net head: 40 m
- Generator: 3 phase synchronous, 950 kVA
- Transformer: 1000 kVA, 0,4/20 kV

Duration of the permit regarding the use of water: until 12/07/2011

Owner's obligations during the operation:

The SHPP will utilize 4/5 of the water supply that circulates in the irrigation channel of the area and will operate throughout the non-irrigation period (October - March). The diversion of water will take place after the approval of the competent LLIO.

Care should be taken to ensure a minimum stable supply within the Enipeas riverbed and downstream of the irrigation channel. The water supply will be higher than the 30% of the average water supply of the Enipeas river during the summer months.

Appropriate metering devices must be installed to enable the measurement of the total flow at appropriate points upstream of the water intakes and the flow that will supply the penstock to the turbines.

After use, the water should return to the natural river flow without any contaminant loads.

ETA Decision modification (XXXX/XXX/01-05-2010)

Modification of ETA decision regarding the location of the power plant, the length of the supply pipeline (penstock) and the incorporation of the intervention approval

decision.

Obligations during the Operation:

1. A small diameter mesh (eye opening) will be installed at the entrance of the irrigation channel to prevent fish (even young ones) from entering the channel throughout the year. The owner must make sure that this mesh is cleaned regularly.
2. Cooperation with the LLIO and local authorities and beneficiaries to ensure a minimum river level after the water intake, which will be sufficient for the development of fish fauna
3. Ensuring that there will be no alterations in the physicochemical characteristics of the water during the operation of the SHPP (i.e. water temperature control checks)
4. Installation or construction of an oil basin around the oil using equipment
5. Preparation of an accident management plan and a site restoration plan to be implemented after the permanent shut down of the plant.
6. Oil and waste management

Duration of the validity of the ETA decision: until 20/05/2020

2.3. Connection Terms

Contructualization of Connection Terms (XXX/XXXX/01-10-2006)

Construction of an aerial grid approximately 0.7 km long

Connection cost 35,000 €

The producer must install:

- A Voltage limit protection relay
- A Frequency limit protection relay
- A Voltage Covalent component protection relay
- An Overcurrent protection relay
- A Synchronization device

2.4. Power Purchase Agreement (PPA)

Power Purchase Agreement Contract (XXXX/01-10-2010)

The Hellenic Electricity Distribution Network Operator (HEDNO) undertakes the responsibility of electric power purchase of a capacity of 850 kW, frequency 50 Hz, nominal voltage 20 kV to be produced by the SHPP

License validity duration: 20 years upon issuance of operation license (until 4/4/2031)

2.5. Installation license

Characterization act (XXXX/01-10-2005)

The Forest Authority characterizes the area of 5,000 m^2 which is part of the plot of land No. 41 as common area of the Zampardiki plot of land as per the land redistribution that took place in 1992 and will be granted to the owner company as a forest area within the meaning of par. 1 of article 3 of Law 998/79 , as amended by article 1 of L.3208 / 2003 par.1.3IIIa and is classified in the category of article 4 par. 1b of the law N.998/79 where the protective provisions of the above law apply.

Payment of usage fee in favor of the State (XXXX/01-10-2006)

A payment of 5,351.5 € is defined as a fee towards the forest authorities in favor of the public in exchange for the land use mentioned above

Installation license (XXXX/XX.X/01-10-2006)

Installation license issuance by the Department of Water Resources Management after a positive opinion of the services mentioned below:

- Directorate of Forest Authority
- Ephorate of Prehistoric and Classical Antiquities
- Ephorate of Byzantine Antiquities
- Ephorate of Modern Monuments
- Hellenic National Defense General Staff (HNDGS)
- The Greek National Tourism Organization

- Directorate of Urban Planning and Environment

Extension of the installation license (XXXX/XX.X/01-06-2009)

Extension by the Water Department for 2 years until 01/10/2010 of the initial installation license (XXXX/XX.4/01-10-2006)

Protocol of Installation in Public Forest Area (01-06-2010)

Installation of a 0.85 MW capacity SHPP power house on a public forest residential area of 4,000 m^2

Building License (XXX/01-07-2010)

Issuance of a building license by the Department of Urban Planning

For hydroelectric projects, a building license is required only for the building of the hydroelectric power house. The designer, the manufacturer and project owner have the entire responsibility of the hydraulic part of the installation.

Small Scale Intervention in the Irrigation Network (XXXXX/01-07-2018)

The owner company must clarify the exact activities and interventions that will take place on the existing irrigation network

2.6. Operation License

Operation License (XXXX/XX.X/01-04-2011)

Granting to the owner company Lamprini S.A., legally represented by Mr. Papadopoulos, based in Domokos, of operating license of SHPP Lamprini of a nominal power 0.85 MW

<u>As built technical characteristics:</u>

- Water intake of an overpass dam from an existing irrigation channel under

the jurisdiction of the LLIO, supplied by the Enipeas springs, at an altitude of + 127.30 m

- Supply duct length 447 m – Φ 1.400 GRP, 446 m – Φ 1.300 GRP, 90 m – Φ 1.300 made of steel
- Power house at an altitude of + 87,3 m, with building dimensions 7,8 m X 16 m X 7,6 m (height) in a plot of land with a surface of 4.000 m^2. The building houses:
    - Water turbine of horizontal shaft Francis type, 860 KW, 750 rpm, 2.200 lt/s, net head: 40 m
    - Generator: e phase synchronous, 800 kVA, 0,4 kV, 50 Hz
    - Oil transformer 1000 kVA, 0,4/20 kV

Liabilities during Operation: The maximum water flow capacity will be 2,220 lt/s utilizing 4/5 of the water supply that circulates in the irrigation channel of the area and will operate throughout the non-irrigation period (October to March).

Validity period of operating license: until 04/04/2031 (20 years)

3. Brief description of the Technical Characteristics and the Operation of the project

Position	Zampardiki plot, Region of Domokos next to Enipeas river, Prefecture of Fthiotida, Circumference of Sterea Ellada
Beneficiary	Lamprini S.A. based at Domokos, legally represented by Mr. Papadopoulos Ioannis
Plot of land surface	4.000 m^2 (Operating License XXXX/XX.X/01-04-2011)
Nominal Power	0,85 MW (Operating License XXXX/XX.X/01-04-2011)

Annual Energy Production	1,9 GW (Production license X6/XXX.XXX/XXXX/01-06-2006)
Operational Period	October to March
Tariff	0,089 €/kWh
Technical Characteristics	Water intake from an overpass dam over an existing irrigation channel under the jurisdiction of LLIO, supplied by the Enipeas springs, at an altitude of + 127.30 m
	Supply penstock length 447 m – Φ 1.400 GRP, 446 m – Φ 1.300 GRP, 90 m – Φ1.300 made of steel
	Power house at an altitude of + 87,3 m, with building dimensions 7,8 m X 16 m X 7,6 m (height) in a plot of land with a surface of 4.000 m^2. The building houses: - Water turbine of horizontal shaft Francis type, 860 KW, 750 rpm, 2.200 lt/s, net head: 40 m - Generator: e phase synchronous, 800 kVA, 0,4 kV, 50 Hz - Oil transformer 1000 kVA, 0,4/20 kV
Licenses validity period	Production license: until 12/06/2031 (25 years) and expendable
	Water usage license: 12/07/2011
	Decision of Environmental Terms Approval: 20/05/2020
	Power Purchase Agreement: until 4/4/2031 (20 years)

	Operating License: until 4/4/2031 (20 years)
Basic operational obligations	Care should be taken to ensure a minimum stable supply within the Enipeas riverbed and downstream of the irrigation channel. The water supply will be higher than the 30% of the average water supply of the Enipeas river during the summer months. Appropriate metering devices must be installed to enable the measurement of the total flow at appropriate points upstream of the water intakes and the flow that will supply the penstock to the turbines.
	The maximum water flow capacity will be 2,220 lt/s making use of 4/5 of the water supply that circulates in the irrigation channel of the area and will operate throughout the non-irrigation period (October to March).
	within the first two months of each calendar year, inform the competent service of the Ministry of Development as well as RAE on the following data relating to the previous year: I. The Annual Energy Production and the Maximum Power Production of the Hydro Power Station recorded during this period. II. The annual percentage of unavailability of the Station and the reasons for which it is due. III. Any operational problems of the Hydro Power Station due to its faults and malfunctions or due to the Medium Voltage Grid
	A small diameter mesh (eye opening) will be installed at the entrance of the irrigation channel to prevent

	fish (even young ones) from entering the channel throughout the year. The owner must make sure that this mesh is cleaned regularly. Cooperation with the LLIO and local authorities and beneficiaries to ensure a minimum river level after the water intake, which will be sufficient for the development of fish fauna
	Ensuring that there will be no alterations in the physicochemical characteristics of the water during the operation of the SHPP (i.e. water temperature control checks)

4. License Content Identification Check

In general, there is an identification of the content of all the basic licenses, except for the Operation License of the SHPP, some of the technical characteristics of which reveal small deviations compared to those of the other licenses:

	Production License ETA decision Water Usage License	Operation License
Water Intake License	+ 130 m	+ 127,30 m
Supply Penstock	length 1.180 m 530m – Φ1.400 GRP, 520m – Φ1.300 GRP, 130m – Φ1.300 made of	length 983 m 447m – Φ1.400 GRP, 446m – Φ1.300 GRP, 90m – Φ1.300 made of

	steel	steel
Power House altitude	+ 87,8 m	+ 87,3 m
Generator nominal power	950 kVA	800 kVA

	ETA decision Water Usage License	Operation License
Plot of land surface	5.000 m^2	4.000 m^2

	ETA decision	Production License
Annual Energy Production	2.103.500 kWh	1.840.000 kWh

During the site visit, the above licensed features will be checked for identification with the installed equipment.

5. Synopsis

Below are listed the remarks that result from the study on the licensing file of the SHPP Lamprini along with the final conclusions of the reliability of the investment in the specific project, as far as its licensing background is concerned.

5.1. Remarks

1. The duration of the ETA decision expires on the 1st of May 2020. If there is no documentation proving the automatic renewal of the aforementioned

license (absence of a relevant document in the project permitting files), the renewal process should begin immediately.

2. The Water Usage License (XXXX/01-08-2006) has expired since 31/07/2011. Normally it should have been renewed but the relevant document is missing form the file.
3. After checking on the notes from DAPEEP S.A. for issuing invoices, on the one hand it seems that the maximum power of SHPP correctly never exceeds the licensed one. On the other hand, the annual productions of 2014 and 2015 show more energy produced than allowed (licensed), which is typically not allowed. Specifically:
    - For the year 2015, 2,262 GWh of energy was produced and invoiced while the production license allows 1.9 GWh. Therefore, for this year, the profits of the SHPP Lamprini were approximately 38,000 € more than the maximum it was entitled to produce.
    - For the year 2016, 2,2 GWh of energy was produced, in other words 360 MWh more than the licensed energy, which is translated to approximately 33,000 € more.
4. This phenomenon is not uncommon. It should first be ascertained whether the 1.9 GWh of energy produced by the Production License (or 2,103 GWh of the ETA decision) is binding for the operation of the SHPP Lamprini and if it is indeed binding, it is advisable to modify the specific licenses so that the SHPP operation permit is increased without modifying any other environmental terms.
5. Regarding the differences identified between the basic licenses (§4), this is also a common phenomenon. It is appropriate to inform the competent services of the characteristics of the installed equipment in order to fully harmonize the licenses with the actual installation.
6. An application for Small Scale Intervention in the Irrigation Network has been submitted (XXXX/01-07-2018). It should be ascertained what exactly the type of operation to be performed is and whether this will affect the operation of the project.
7. It remains to be certified during the site visit that the rules and operational restrictions of the SHPP Lamprini are observed by its administrator as they

are described in its basic licenses.

8. It is noted that the legal validity of the existing permits and contracts of the project with external entities and services, as well as the concession of the forest land is not controlled by the present study and is taken for granted. Any legal defects can be investigated by lawyers only.

5.2. Conclusion

On its whole, the licensing process of the SHPP Lamprini is considered to be correct and generally complying with the laws and regulations, which is demonstrated by the normal operation of the project since November 2012.

Some shortcomings and small inconsistencies were identified, which, however, are common. They are manageable and they do not affect the continuation of the project's operation.

CHAPTER C – TECHNICAL ANALYSIS AND EVALUATION AFTER AN ONSITE VISIT

1. Introduction

In the Chapter B a technical evaluation is being held on the SHPP Lamprini, based on the site visit that took place on Monday 10th of May 2021.

Firstly the technical evaluation of the equipment takes place, then the mode of operation of the project is examined and lastly, the final conclusion of the evaluation of the SHPP Lamprini is presented.

2. Technical Evaluation of the Equipment and the Sections of the SHPP

The evaluation concerns the equipment and the individual parts of the project and includes:

- ✓ Identification of the licensee with the installed equipment
- ✓ Evaluation of the general technical condition and the maintenance of the project
- ✓ Identification of possible external hazards for the equipment and operation of the SHPP
- ✓ Proposals for upgrading the existing installation, with their respective estimated costs (plus its operating costs)

2.1. Enipeas Springs

The management of Enipeas resources is the responsibility of the LLIO. However, the operation of the intake installation during the operating period of the project is done by the local operator of the SHPP.

The owner company of the SHPP and the LLIO are co-responsible according to the

licensing file of the SHPP for the existence of a mesh at the entrance of the channel so that no fish enters inside. This mesh has already been installed. However, since its automatic cleaning has not been ensured, it often clogs, reducing the flow of water to the channel and consequently to the SHPP. In order to avoid production losses, the owner company has decided to leave the grid open and the water to flow unobstructed into the canal. According to the local operator of the SHPP: there are no fishes in the river, the local services are aware of the non-use of the grid and do not react, while the LLIO is an ally of the owner company because it also benefits from its non-use.

Water intake and protection mesh at the springs of Enipeas

There are also no metering equipment that certify that the obligations of the SHPP regarding the use of water are met.

Mesh installation evaluation:

- The installation is satisfactory but practically not used.

Possible risks:

- An environmental authority may react to the non-use of the mesh and either impose a fine or require its use, which will reduce the production of the project.
- Reactions may also result from the non-use of metering equipment for the supply of river water.

Upgrades proposals:

- A fish fauna study can be performed to prove the presence or absence of fish in the river. In case there are no significant fish populations, a request can be made to modify the Environmental Terms of the project and the term for the use of the mesh can be removed. The estimated cost is approximately € 3.000 € for the study of fish fauna and approximately 2.000 € for the modification of the Environmental Terms.
- In case the above proposal does not work, and the competent local authorities require the use of the mesh, the installation of an automatic cleaner with brushes should be evaluated. However, the cleaner should also have a power supply and according to the local operator there is no grid in the area. In this case it should be autonomous. It is not possible to make a safe estimate of the cost of the installation due to the specificity of the point. Indicatively, this could range from 15.000 – 25.000 € depending on the power supply of the equipment.
- According to the permits of the SHPP, a system for measuring the flow of water of Enipeas river should be installed and the minimum ecological supply to the river should be ensured. The cost for this upgrade is approximately 5.000 – 10.000 €

2.2. LLIO irrigation channel

The LLIO will not be using the channel starting from October 1st. The channel is closed in order to empty the water and then the local operator of the SHPP Lamrini takes care of its cleaning with the appropriate machinery equipment (JCB, shovel) and manually by 2 workers. The cleaning works usually takes 5 to 7 days. Then the

channel is filled again and, depending on the amount of water, the operation of the project begins.

Along the channel there are 9 water gates for holding debris and animals that may fall into the channel. It is the obligation of the owner company and the LLIO to take care so that animals do not risk falling into the channel.

Irrigation channel and water gate

In case of operation interruption of the SHPP due to equipment failure or grid interruption, the channel overflows and opens the gate that is installed after the loading tank of the SHPP. As a result, the water is not retained in the channel, there is no required operating level in the loading tank and the gates at the Enipeas springs must be properly handled in order for the SHPP to get back to operation.

Channel water gate next to the loading tank

Evaluation:

- In general, the condition of the irrigation channel is very good
- The condition of the water gates along the channel is satisfactory

Risks:

- In case of denunciation, the necessary measures to protect the animals from falling into the river are not in effect (in the past even cows have fallen in).

Upgrade proposals:

- Earthmoving may take place in order to create a bypass outlet of the channel, so that it does not overflow in case of grid failure and the restoration of the operation of the SHPP can be achieved sooner with a profit of at least 2 hours of operation per event. The cost according to the local operator of the SHPP is estimated at 5.000 € and there is already a positive opinion on the relevant works form the local authorities.
- Additionally and in cooperation with the LLIO, it would be useful to upgrade the water gate of the channel at the point of the loading tank, so that it is

possible to adjust its opening. In this way the adjustment of the operating level of the SHPP will be achieved faster after any power grid interruption. The estimated cost is 5.000 €

- In order to ensure the safety of the animals from falling into the channel, a guardrail or a safety fence could be installed. However, since the length of the channel is remarkable (over 5 km), this upgrade could only take place only in cooperation with the LLIO. It should be noted that this is required for environmental issues and no financial profit should be expected, given that it is highly unlikely that the local authorities will denounce this.

2.3. Water Intake

The water intake of the overpass dam from the existing irrigation channel of the LLIO is confirmed. However, it seems to be installed at an altitude of about + 121 m, in contrast to the + 130 m of the Production License (as well as the ETA decision and the Water Usage License) and the + 127.3 m (Operating License). This, in fact, only affects the production of the project which is slightly reduced by its nominal operation due to the smaller nominal altitude difference. From a licensing point of view, it is something that can be easily corrected if requested.

Water Intake

The water before entering the supply penstock, is collected in the loading tank, where there is an automatic trash rack cleaner with adjustable cleaning frequency every 10 minutes that ensures the purity of the water from leaves and branches. Damages suffered at the automatic trash rack cleaner in the past concern the piston and the flexible hydraulic hoses, which are easily repaired and at low cost.

Automatic trash rack cleaner

Loading tank

Evaluation:

- In general, the quality of the automatic trash racks cleaner's construction is satisfactory
- The installation is sufficient for the amount of the floating debris that need to be cleaned
- The condition of the trash racks in the loading tank tank is quite good
- The piezoelectric water level meter sensor in the loading tank is excellent
- The maintenance quality of the automatic trash racks cleaner is mediocre. Regular cleaning of the equipment and better insulation of the control housing are required

Hydraulic unit and automatic trash racks cleaner control lodge

Possible risks:

- In the event of a large animal falling into the channel, the cleaning beam of the automatic cleaner may be crooked. In this case, it can be repaired in a machine shop with relatively low cost depending of course on the distortion (< 300 €)
- Piston and hydraulic piping failure of the automatic cleaner, which may occur every about 2 years but with a small cost of restoration (< 1.000 €)

Upgrade proposals:

- Installation of a desander channel and a flashing water gate in parallel with or by modification of the irrigation channel. This upgrade will help in the purity of the water which implies greater protection of the turbine and slightly increased production per year, as it will not be necessary to stop the unit for a long time when the water is very blurred from mud and sand. An estimated cost is 15.000 €

2.4. Road network and penstock supply

The water supply penstock from the water intake to the SHPP is installed underground along its entire length, while it ends concrete boxed in its last section before the power house. There are no vent valves, cleaning pipettes, manholes inside the duct and cathodic protection. Moreover, this is not required due to the construction material (GRP) and the smooth course and slope of the pipeline

Concreted penstock

Evaluation:

The condition of the road to the water intake (~ 3km) is quite good as it is a provincial dirt road

Road from the village to the water intake

The condition of the road to the power house is quite good while there is a second shorter road to the power house which is in poor condition.

Road from the water intake to the power house

Probable equipment risks:

- There are no several photos from inside the supply penstock but there are no serious risks for both the pipeline and the condition of the roads for the water intake and the power house.

Upgrade proposals:

- The second road to the power house could be improved but it is not necessary. It seems that a small maintenance from time to time by the local site operator is sufficient for safe access to the SHPP and its water intake.

2.5. Power house

The power house is located at an altitude of approximately + 91 m, in contrast to the + 87.8 m of the Production License, the AEPO and the Water Usage License, as well as the + 87.3 m of the Operating License.

The area of the building is approximately 120 m^2 and its dimensions are 7.8 m X 16 m X 7.6 m (height) in an installation field of 4,000 m^2.

Power house

Regarding the protections of the building, there is lightning protection (surge arresters), grounding copper bars, retreaded fire extinguishers but not an automatic fire extinguishing system with SMS notification.

Surge arrester

Grounding copper bars at the M.V. cubicles and the L.V. panels

Retread Fire Extinguisher and Fire Nest

There is also a crane bridge with a nominal lifting capacity of 10 tn which will serve in case of such a failure of the turbine or the generator that the removal of equipment is required for its repair. The crane bridge is inspected and certified using a water tank for a lower weight (7 tn) than that of its nominal lifting capacity, which is sufficient to lift the generator (5.5 tn). The generator is the largest load that may require lifting.

Crane bridge and water tank for lifting, for its certification

Building installation evaluation:

- The condition of the building is quite good, as there are no cracks and traces of leaks or moisture.
- The condition of the surrounding area is satisfactory. Only the repair of the fence and some grass cutting is required for safety reasons (snakes and fire hazards)

- The state of lightning protection (surge arresters) looks good but in order to give an opinion with certainty, an appropriate measurement must take place (low cost < 500 €)
- The condition of the grounding installation seems good, while it is taken for granted that the equipotential mesh is there for the protection of the personnel working in the area. To ensure that, one must take the appropriate measurements (with low cost < 500 €)

Probable risks:

- The differences between the actual altitude of the power house and the licensed one are not significant and can be easily updated upon request.

Upgrade proposals:

- No special upgrades are required at the power house and in the surrounding area, except for the regular grass cutting and the repair of the fencing (estimated cost < 500 €)

Fencing of the power house

2.6. Main Inlet Valve

It is confirmed that the installed main inlet valve is the TBHydro - DN800 PN6 - Type BTV - 01 / BTV / 1302/2010.

No water or oil leaks were detected from the hydraulic unit. Also, according to the

owner company, the central valve has never been changed. There is no drainage pump under the main valve, but there is a siphon to drain any probable water leakages.

The penstock pressure is measured at 3.2Bar, which indicates that the altitude difference is about 32m and not 40m as mentioned in the licenses, but this does not constitute a licensing issue.

Main Inlet Valve label

Main Inlet Valve and bypass pipe

Draining siphon

Evaluation of Main Inlet Valve:

- The Main Inlet Valve is in a very good condition
- All the measuring equipment on the Main Inlet Valve are fully operational (no calibration certificates are available though)

Probable risks:

- There is no imminent risk on the health status of the equipment

Upgrades proposals:

- No Main Inlet Valve upgrades are required. An automatic drainage system could be installed, but it is not necessary as no leaks have been observed

2.7. Hydraulic Unit

The hydraulic unit is made by Bosch Rexroth. According to the local plant operator, the accumulator bladder has never been replaced, the hydraulic piping has never been replaced either and nitrogen filling has never been required. The filters and the oil are being replaced every 2-3 years by an external partner (contractor).

Hydraulic Unit's label

Hydraulic Unit evaluation:

- The hydraulic unit is in very good condition and the fact that it is made by Bosch Rexroth ensures the ease of finding spare parts in the future (when needed).
- All the measuring instruments of the hydraulic unit seem to be working properly (no calibration certificates are available though)

Probable risks:

- The fact that accumulator bladders and the flexible hydraulic piping have never been replaced implies that this will be required quite soon

Upgrades proposals:

- No hydraulic unit upgrade is required. However, it is useful to prevent the accumulator bladder from being stopped as a precaution during operation (cost approximately € 900) while in the future (as soon as oil leaks begin to occur) the hydraulic piping will need to be preventively replaced (cost around € 400). Both those 2 activities should be part of the periodic scheduled maintenance of the plant

2.8. Water Turbine

The water turbine, manufactured by Geppert, is of a Francis horizontal axis type and has a nominal operating power capacity of 860 kW (as opposed to its licensed power of 850 kW). The nominal flow is 2,200 lt / s and the nominal rotating speed is 750 rpm. The altitude difference with the water intake (gross head), as mentioned, is about 32 m instead of the 40 m mentioned in the permit. This means that the turbine cannot operate at its maximum power, as defined by its nominal characteristics. The difference between licensed and installed power capacity can be easily updated by modifying the existing licenses (if required).

The water turbine has a vibration sensor installed, which is displayed on the SCADA and is useful for the timely prevention of serious equipment failure. This is an advantage of the installation.

According to the local site operator, a crack penetrant test has been performed on the runner and there were no signs of cracks.

The water turbine showed no signs of water or oil leakage on the day of the visit. However, according to the local operator of the owner company, the turbine showed an important water leakage in the past and was repaired by casting the base of its blades. No leakages appeared ever since.

As the exit of the turbine (tail race), the water flows unimpeded back to the river bed without a water gate. Due to the difference in altitude with the river level, the presence of the gate is not necessary and could be installed only to prevent small animals from entering the turbine's draft tube.

Water turbine label

Francis horizontal axis type turbine

Turbine tail race

Water Turbine evaluation:

- The turbine seems to be in a good condition with a slight reservation however. During the day of the site visit, the SHPP was in operation and it was not possible to remove the turbine cone in order to perform an autopsy of the condition of the impeller internally.
- In addition, the turbine cannot operate at its nominal capacity (760 kW). The maximum operating power of SHPP that has been recorded by LAGIE is 679 kW.
- All turbine operation, measurement and monitoring instruments are working properly (no calibration certificates are available though)

Probable risks:

- The water leakage that has occurred twice in the past is worrying and may recur in the future. However, the last restoration was done by a reputable company (Poseidon) and it is quite possible that the problem has been resolved, at least for the next 2-3 years.

Upgrade proposals:

- In case of recurrence of water leakages in the future, the impeller will have to be remodeled by casting the base of more blades (the estimated cost is 5.000 – 10.000 €)

2.9. Generator

The generator is made by Hitzinger, with a type SGK 9B 08T / K10605 and has a power of 800 kVA, instead of 950 kVA as mentioned in the licenses. Its other features are as stated in the licenses.

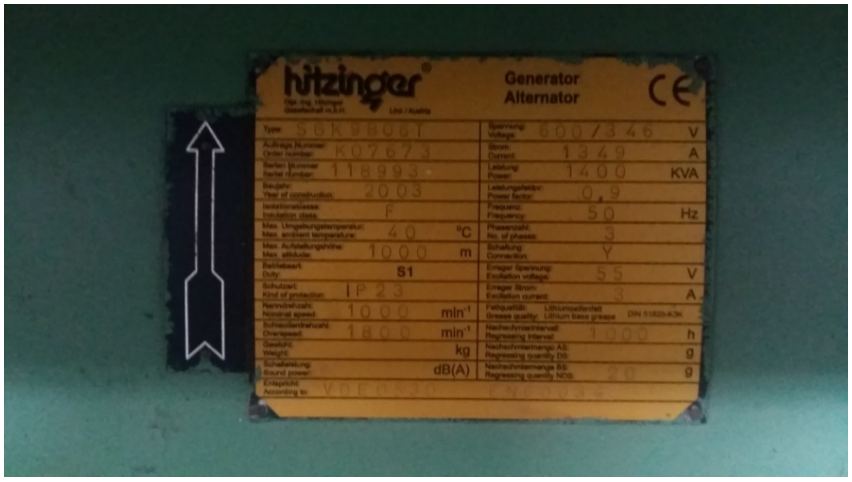
According to the engineer and the local operator of the SHPP, the Automatic Voltage Regulator (AVR) and the cosφ (Power Factor) of the generator have never been replaced before.

Never before has a megger test been applied to measure the generators insulation and never have the generator's protections been tested by infusing fault measurements.

The oil is replaced every 2-3 years, while it has never been analyzed. Grease filling is done systematically by the local operator according to the generator's operation manual.

The temperature readings of the bearings and windings look correct, but there is no temperature history recorded on the SCADA.

During the visit to the SHPP, no unusual noise was heard from the generator bearings, while by hand, the vibrations and temperatures were normal.



Generator's label

Generator

Non Drive End bearing greaser

Generator evaluation:

- The generator appears to be in a good condition. However, this is stated with a slight reservation due to the unavailability of the hydro plant's log book (a book recording all events that took place).
- The fact that the AVR has never been replaced in the past is positive, while in addition, the generator has no signs of movement from its original location of installation which proves that it never had to go out of site for repair.

Generator foundation without signs of displacement

Probable risks:

- There are no serious risks menacing the generator's health status, however it will be useful to perform:
    - Oil analysis in order to have a greater picture of the condition of the bearings (estimated cost 150 €)
    - Megger test to verify the correct insulation of the generator's windings (cost < 300 €)
    - Fault alarms infusion in the protection relay in order to confirm the correct operation of the generator's electrical protections (estimated cost € 2,000).

Upgrade proposals:

- In case the low temperatures in the area during the winter affect the operation of the generator, it would be useful to install additional heaters for better heating and dehumidification of the generator windings especial during starting the unit up (estimated cost around € 1,000)

2.10. PLC - SCADA

The PLC and the SCADA are manufactured by EN-CO. Remote handling of the project is possible.

All measuring and control instruments during the visit to SHPP were functional. The SCADA after a remote connection in collaboration with the project engineer does

not seem to keep historical data beyond the last few months.

The UPS used for the station's telecommunications is not industrial type, while the PLC batteries can power the Low Voltage up to 2 days long.

Low Voltage Panel (PLC)

Operation measuring instruments

<u>Equipment evaluation</u>:

- EN-CO's SCADA doesn't seem really user friendly. However, it is quite positive the fact that all signals of the SHPP are displayed as well including

those from the Medium Voltage.

- The fact of not storing historical data in the SCADA (beyond 6 months), makes it difficult to properly assess the operation of the SHPP in the past
- Apart from the above, there is no significant history of faults other than the frequent burning of the module where the temperature sensor of the Drive End bearing of the generator is connected. This error is considered minor but should be investigated the next time it occurs.

Probable risks:

- There are no particular risks for the automation of the SHPP

Upgrade proposals:

- The SCADA should be evaluated with its use and in the long run. Historical data is necessary. In case it is deemed insufficient, it will have to be replaced with an estimated cost of approximately 10.000 – 15.000 €
- The SCADA operation should be investigated. A probable upgrade could include the recording of all historical data

2.11. Medium Voltage Cubicles

The Medium Voltage Cubicles are made by Siemens. The maneuvers are being performed by an external partner (qualified engineer), while locally there are some basic Personal Protection Means (PPE).

Medium Voltage Cubicles

Medium Voltage Protection Relay

Equipment Evaluation:

- The Medium Voltage cubicles appear to be in pretty good condition and according to the SHPP's engineer, they never suffered any serious damages in the past.
- The Medium Voltage protection relay is fully functional
- No Megger test has been performed to determine the insulation status of the Medium Voltage cables.
- The Medium Voltage cubicles frounding appears to be in a good condition
- The Personal Protective Equipment for the MV maneuvers are insufficient and thus, every time this is required, the external partner (qualified engineer) must bring his own PPEs for any work in Medium Voltage
- There is no fire extinguisher for the Medium Voltage section

Probable risks:

- There are no significant hazards to the equipment, however a Megger test is required to check the cables' insulation between the Transformer and the MV cubicles (estimated cost < 300 €)
- Electrical protections check is required at the protections' relay (estimated

cost of 1.000 € - 2.000 €)

- In case the external partner is not a qualified and experienced engineer and he does not use PPEs for performing MV maneuvers there is a serious risk of electric shock to the staff

Upgrade proposals:

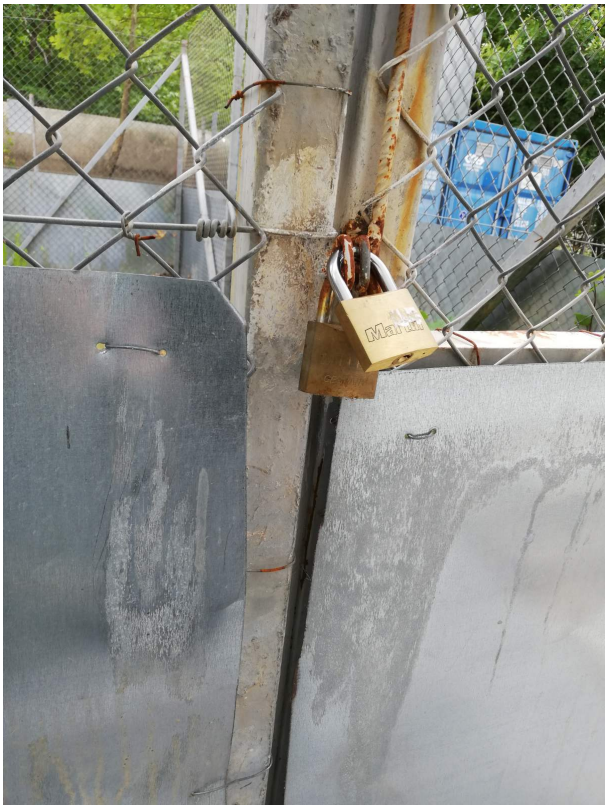
- A complete PPE panel must be purchased (cost estimation for Sofamel panel is approximately 1.000 €)

2.12. Transformers

According to the responsible Engineer of the project, the operation and maintenance of the Transformers (Main and Auxilliary transformer) is the responsibility of the HEDNO. Therefore there are no reports from maintenance and oil analysis.

There is no interlocking system to prevent from accessing the area of the transformers without having isolated and grounded the electrical circuit.

Main and Auxiliary transformers



Access to the transformers' area without interlocking

Equipment evaluation:

- The transformers seem to be in a good state. In any case, their responsibility belongs to HEDNO (according to the project engineer)

Probable risks:

- There are no any evident hazards for the equipment
- There is a risk to the safety of local workers as long as there is no interlocking system to prevent accessing the of the transformers

Upgrade proposals:

- In cooperation with the HEDNO, an interlocking system installation must take place for the safe access into the area of the transformers only after they have been isolated and grounded first.

2.13. Hand Tools

The tools at the SHPP are minimal and substandard. Since the maintenance and repair works are being performed by external partners, the existing set of tools may be sufficient.

The possibility of purchasing new more specialized tools (i.e. multimeter, megger, torque wrenches, etc.) should be evaluated in the long run.

In case of acquisition of the project, it should be ensured that the few existing tools will remain in the property of the SHPP and will be owned by the buying company.

Tools shelves and special tools

2.14. Logistics

There are no Major Components but they are not required for such a small project.

There are a few spare parts such as fuses and a water level sensor. Purchasing more spare parts should be evaluated in the long run.

The Oil storage conditions are not suitable. The sealing of the barrels and cans and the purity of their content should be ensured as it is of the utmost importance for the integrity of the equipment's (generator) health status. Oil pans should also be installed for environmental reasons, in order to protect against oil spills on the floor.

Regarding waste, a waste management procedure should be followed even for the plants minimal waste quantities. No waste and oil management dossier has been found in the SHPP files.

3. Operation

The operation of the small hydro plant is being examined right below

3.1. Standard Operation - Omissions

As mentioned in § 2.1, there is a small diameter mesh (eye opening) at the channel entrance, but it is not being used. The actions required have already been mentioned.

As mentioned in § 2.1 there are no metering devices for measuring the flow of the river Enipeas. Furthermore, a specialized book is not being filled for recording the flows of Enipeas river and the water flow that is supplying the SHPP. This phenomenon is common and any possible sanctions that can be imposed depend on the local environmental services (Directorate of Environment and Directorate of Water).

As mentioned in § 2.2, there is no protection against falling animals in the TOEB channel.

As mentioned in § 2.14, no waste management procedure is being followed.

It is the obligation of the owner company of the SHPP to ensure that there are no alterations in the physicochemical characteristics of the water during its operation. Generally, this is not common among the hydroelectric power plants, but the owner company should also be able to demonstrate this by conducting and recording water temperatures before and after the producing units, or by taking water samples before and after the plant for chemical analysis (the estimated cost is 100 - 200 € per year)

The discrepancies between the licensed features of the SHPP and the actually installed ones can be corrected by updating the existing licenses, if requested. Until then, there is no particular risk for the continuation of the operation of the SHPP.

3.2. Operation – Energy Production

The owner company has not been able to prove the non-operation of the SHPP during the following periods (according to the invoices to LAGIE):

- from October 2016 until part of February 2017
- from October 2018 until mid-December 2018
- part of January 2019

The log book of the SHPP has not been made available and additionally, it is not possible to display historical data in order to check the above periods on the SCADA.

The non-operation of the project may be due to lack of water, but equipment problems cannot be ruled out.

3.3. Local responsible – Operator of the SHPP

The local operator is unskilled in terms of technical education without computer skills and the operations he performs at the SHPP are of limited range and mainly manual. He has not been trained in safety, environmental and health issues and in case of continuing the cooperation with him, he will need to receive the relevant trainings (first aid, safe driving, risks of working in electromechanical installations). In addition you will need to be supplied work clothes and Personal Protective Equipment (safety shoes with electrical protection, helmet and vest)

It is a positive fact that he has his own machinery which he uses for cleaning the irrigation channel. These machinery must be insured during any sort of works.

He is constantly supervising the project and shows significant responsibility and sense of ownership for its proper operation. However, he could be more involved in the maintenance of the SHPP (equipment cleanings, more visual checks, etc.) and the cleaning of the building as well as the surrounding area (grass cutting, painting, fence repairing etc.).

His good relationship with the people of the LLIOB and the local contractors, prove him to be important for the operation of SHPP as he plays an key role for the positive image and the good relations of the company with the local community.

Finally, his car is in satisfactory condition. The purchase of the car could be accompany the purchase of SHPP.

3.4. Operating Expenses

Operating costs have already been announced by the owner company to the interested company. In a probable purchase of the hydro plant, the new owner company should also consider the following operational costs:

- 2 visits per year of a safety technician

- 1 visit per year of an occupational doctor

It should also be borne in mind that maintenance costs may increase slightly with the aging of the equipment. Good maintenance of the SHPP is necessary to maintain the generally good condition of the equipment.

4. Conclusion

As a whole, the equipment and the facilities of the project are considered to be in a quite good state. As this is a relatively new hydro plant, it could be considered that the risk of any significant and costly damage is small and not greater than that of any properly installed new hydro project. Even during a force majeure, there doesn't seem to be any important risk at the surroundings of the plant.

The fact that the whole facility is installed on smooth ground and the water is not taken from a river but from an irrigation channel, significantly increases its reliability and reduces the risk of the investment. In addition, the existing installation will most likely be able to operate for many years more and certainly after the original operating license as no significant damage is expected.

The main risk of a costly equipment failure is located in the turbine, as reported in the paragraph § 2.8

On the downside it should also be noted that while the rated and licensed power of the SHPP is 850 kW, its actual power is 679 kW, which is the maximum operation it has achieved to date. This is mainly due to a reduced altitude difference between the water intake and the turbine, which is about 32 m (instead of 40 m).

The annual productions of the SHPP are evident from the invoices to LAGIE and it seems that they can hardly increase significantly. To do this, upgrades must be made as described above (mainly in the channel and the channel water gates). The evaluation and selection of upgrades should be done in the long run and based on the experience of the operation of the project to avoid possible failures and waste.

Finally, it is noted that for the preparation of the study all the information, photos and financial data provided by the owner company and used in this evaluation were considered to be true as it was not possible to access the project's log book and its historical operating data from the SCADA.

To reduce the risk of the investment it is recommended to negotiate to include a clause which will bind the current owner with:

- Repair of any current damage that has not been revealed and remains unrepaired until the date of the final transfer from the current owner to the interested investor.
- Future repair of any damage that may occur in the next 2 years on any part of the equipment that had failed in the past and as an event, it has not been revealed by the technical feedback that was provided by the owner company.
- Compensation for loss of production in case of an external factor that has not been revealed by the owner company and may prevent the normal operation of the project under the normal conditions and periods of operation

CHAPTER D – ECONOMICAL EVALUATION

1. Introduction

In the Chapter C, an economical check is being performed, based on the invoices and the profits of the hydro plant. Additionally, the maximum power production is notified in order to verify that the plant's operation complies with the issued licenses, as indicated in Chapter A.

According to this check, an estimation of a bidding price will be defined.

2. Actual Economical Profits

The economical profits of the SHPP Lamprini appear in the tables below:

	2012			2013		
	max Power (kW)	Annual Energy (kWh)	Annual Revenues (€)	max Power (kW)	Annual Energy (kWh)	Annual Revenues (€)
January				642	395.752	35.605,81 €
February				658	339.192	30.517,10 €
March				626	422.301	37.994,42 €
April				639	338.064	30.415,62 €
May				326	3.196	287,54 €
June				0	0	- €
July				0	0	- €
August				0	0	- €
September				0	0	- €
October				0	0	- €
November	477	121.920	10.887,46 €	559	33.930	3.052,68 €
December	553	270.872	24.188,86 €	557	238.982	21.501,21 €
max/total/total	553	392.792		658	1.771.417	159.374,39 €
€/kWh			**0,08930 €**			**0,08997 €**
Check	OK	OK		OK	OK	
Extra Energy						
Extra Revenues						

	2014			2015		
	max Power (kW)	Annual Energy (kWh)	Annual Revenues (€)	max Power (kW)	Annual Energy (kWh)	Annual Revenues (€)
January	619	414.382	37.281,95 €	599	399.219	35.530,49 €
February	633	323.578	29.112,31 €	612	378.599	33.695,31 €
March	652	406.867	36.605,82 €	639	416.282	37.049,10 €
April	589	329.998	29.689,92 €	572	154.022	13.707,96 €
May	0	0	- €	0	0	- €
June	0	0	- €	0	0	- €
July	0	0	- €	0	0	- €
August	0	0	- €	0	0	- €
September	0	0	- €	0	0	- €
October	451	44.232	3.979,55 €	612	124.128	11.047,39 €
November	599	327.932	29.504,04 €	608	355.619	31.650,09 €
December	660	422.158	37.981,56 €	596	402.216	35.797,22 €
max/total/total	660	2.269.147	204.155,16 €	639	2.230.085	198.477,57 €
€/kWh			**0,08997 €**			**0,089 €**
Check	OK	FALSE		OK	FALSE	
Extra Energy		429.147			390.085	
Extra Revenues			38.610 €			34.718 €

	2016			2017		
	max Power (kW)	Annual Energy (kWh)	Annual Revenues (€)	max Power (kW)	Annual Energy (kWh)	Annual Revenues (€)
January	612	411.128	36.590,39 €	0	0	- €
February	622	401.252	35.711,43 €	612	259.142	23.063,64 €
March	634	418.252	37.224,43 €	624	408.002	36.312,18 €
April	602	169.832	15.115,05 €	593	186.932	16.636,95 €
May	458	1.584	140,98 €	0	0	- €
June	0	0	- €	0	0	- €
July	0	0	- €	0	0	- €
August	0	0	- €	0	0	- €
September	0	0	- €	0	0	- €
October	0	0	- €	0	0	- €
November	79	32	2,85 €	312	8.928	794,59 €
December	0	0	- €	679	405.128	36.056,39 €
max/total/total	634	1.402.080	124.785,12 €	679	1.268.132	112.863,75 €
€/kWh			**0,089 €**			**0,089 €**
Check	OK	OK		OK	OK	
Extra Energy						
Extra Revenues						

	2018			2019		
	max Power (kW)	Annual Energy (kWh)	Annual Revenues (€)	max Power (kW)	Annual Energy (kWh)	Annual Revenues (€)
January	671	407.589	36.275,42 €	599	272.151	24.221,44 €
February	614	364.832	32.470,05 €	619	365.312	32.512,77 €
March	618	398.215	35.441,14 €			
April	552	110.232	9.810,65 €			
May	0	0	- €			
June	0	0	- €			
July	0	0	- €			
August	0	0	- €			
September	0	0	- €			
October	0	0	- €			
November	0	0	- €			
December	493	107.282	9.548,10 €			
max/total/total	671	1.388.150	123.545,35 €	619	637.463	56.734,21 €
€/kWh			**0,089 €**			**0,089 €**
Check	OK	OK		OK	OK	
Extra Energy						
Extra Revenues						

3. Conclusion

The average gross revenues of the hydro plant is 155.000 € which means that it hasn't reached its maximum potential.

Given that:

- the plant has been in operation since 2012, it means that the depreciation of capital has already been completed.
- It can operate with annual gross revenues at approximately 200.000 €
- The plant's operation license will be renewed after its ending date

Therefore a fair price for both parties would be the maximum estimated revenues of 4 years, thus 800.000€. The bidding company should not exceed this amount.

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