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Thesis:

"Feasibility and environmental appraisal of a small hydro-power plant."

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I would like to thank Mr Georgakellos for his valuable help. Without his advice and material support it would not have been possible to complete this task. I thank him sincerely for our perfect collaboration and his contribution to the completion of my thesis.

I dedicate this thesis to my family and friends who were beside me and supported me throughout these years!!!

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Περίληψη

Είναι γνωστό ότι σήμερα , η υδροηλεκτρική ενέργεια κατέχει κυρίαρχο μερίδιο στην παραγωγή ηλεκτρικής ενέργειας από ανανεώσιμες πηγές.Βέβαια,η ενσωμάτωση των Μικρών Υδροηλεκτρικων Σταθμών στο ενεργειακό σύστημα στην Ελλάδα είναι περιορισμένη. Παρά τους όποιους δισταγμούς για σοβαρές επεμβάσεις στο φυσικό περιβάλλον κατά την κατασκευή τους ,δεν μπορεί να υπάρξει καμία αμφιβολία ότι η σημασία των Υδροηλεκτρικών Έργων για τη διαχείριση των υδάτινων πόρων στην Ελλάδα είναι πολύ μεγάλη, καθώς τα περισσότερα από τα έργα αυτά χρησιμοποιούνται για πολλαπλές χρήσεις όπως για παραγωγή ηλεκτρικής ενέργειας ,για ύδρευση, άρδευση ,για έλεγχο των πλημμυρών ,για αναψυχή ,υδατοκαλλιέργειες καθώς και αθλητικές δραστηριότητες οι οποίες συμβάλλουν στην ήπια τουριστική ανάπτυξη της χώρας.

Με βάση τα παραπάνω, η παρούσα εργασία εξετάζει τη συμβολή των Μικρών Υδροηλεκτρικών Έργων ως προς το όφελος της κοινωνίας ,της οικονομίας ,του περιβάλλοντος και της ενεργειακής απόδοσης της Ελλάδα και πιο συγκεκριμένα στο νομό Ευρυτανίας .Η παρούσα διπλωματική παρουσιάζει τις βασικές αρχές της λειτουργίας και εγκατάστασης των υδροηλεκτρικών έργων ,κάνει μια αναφορά στους ήδη υπάρχοντες μικρούς υδροηλεκτρικούς σταθμούς στην Ελλάδα.Επίσης γίνεται μια ειδική αναφορά στις περιβαλλοντικές επιπτώσεις ,την ευρύτερη διατήρηση και την προστασία του περιβάλλοντος, καθώς και μια εκτίμηση του κόστους της παραγωγής ηλεκτρικής ενέργειας από υδροηλεκτρικούς σταθμούς και μια αξιολόγηση των εξωτερικών περιβαλλοντικών δαπανών.Μέσα από αυτή τη μελέτη θα αξιολογηθεί η σκοπιμότητα του έργου μέσω της μελέτης των οικονομικών και άλλων στοιχείων αυτής της επένδυσης .

Λέξεις κλειδιά: Μικρός Υδροηλεκτρικός Σταθμός ,Ανανεώσιμες Πηγές Ενέργειας, Ανάλυση Κύκλου Ζωή

Abstract

It is well known that, hydropower currently holds a dominant share of electricity production from renewable sources. Of course, the integration of Hydroelectric Project in the energy system is limited in Greece. Despite any hesitations for serious interventions in the natural environment, there can be no doubt that the importance of Hydroelectric Projects on the management of water resources in Greece are very large, as most of these projects are multi-purpose as they are used for electricity generation, water supply, irrigation, flood control, recreation, aquaculture, and sport activities contribute to mild tourism development in the country.

Based on the above,the present thesis examines the contribution of the Hydroelectric Projects in benefiting the society, economy and environment and energy efficiency in Greece and more specifically in the prefecture of Evrytania. It presents the basic principles of operation and installation of hydroelectric projects and makes a reference to the existing SHP in Greece .There is specific reference to the environmental impact, the wider conservation and environmental protection as well as an estimation of the cost of electricity's production from hydroelectric stations and an evaluation of the external environmental costs. Through this study we will evaluate the feasibility of the project and assess the economic and other elements of this investment.

Key words: Small Hydro plant, Renewable Sources,LCA

Chapter 1 - Summary of the the project

1.1 Energy and HP

Energy has always been a key public good, necessary for the growth and development of the societies. In recent years, energy issues concerning the production, management and its relationship with contemporary environmental issues such as global warming and the impending exhaustion of conventional energy reserves are at the center of attention at national and global level.

The energy sector is now a key factor in decision-making and policymaking related to economic, social and technological issues.

Greece has developed a “National Information System for Energy” .The system which is accessible through the Ministry of Development website (www.ypan.gr), has been created to assist in monitoring the energy sector and support decision-making in energy policy. Other related websites include: CRES (www.cres.gr), RAE (www.rae.gr), HTSO S.A. (www.desmie.gr), Institute for Environmental Research and Sustainable Development of the NOA (www.climate.noa.gr) etc. There are also some special e-pages which provide scenarios and examples of applied case studies for special cases with step-by-step practical guidelines/manuals (e.g. power supply to isolated villages by using hydro). Information on climate change policies is provided on YPEHODE’s URL (www.minenv.gr)

The momentous developments and reforms in the international energy sector as soaring international energy raw materials creates new standards for producing electricity. The importance of water resources as a source of power upgrades and thus gain increasing international investment and economic interest.

The soaring levels, therefore, of the international prices of oil and natural gas requires energy import dependent countries to move closer to a better exploitation of domestic water resources and development of Renewable Energy Sources (RES). The cost of producing electricity from the energy of the river becomes more attractive compared with that based on imported energy materials. Already hydropower has the lower cost of all the other sources of electricity generation (except nuclear).

Moreover, the liberalization of electricity markets and the breaking of monopolies in the European Union opened the way for greater utilization of the water resources of the country through private investment in small or large hydropower projects. The interconnection of the national electricity transmission networks between the countries of the European Union and the third countries contributed to the rapid internationalization of electrician trade which builds low-cost production from hydropower.

Thus, through the production of electricity from hydropower we can ensure reduction of CO^2 emissions and reduction of the dependence on imported energy. It is therefore an urgent need for efficient collection and management of water resources through hydroelectric plant.

1.2 Structure of the work

The present work deals with the contribution of hydropower to generate electricity specifically for Greece. Structured in accordance with the basic principles of a technical-scientific text, and is divided into eleven chapters.

More specifically, the second chapter is an introduction and a presentation of the historical exploitation of hydropower. There is brief reference to the need for efficient collection and proper management of water resources through the use of hydroelectric power.

The third chapter refers to the principles of operation of hydropower. Basically, there is a description of the operation of a hydroelectric power plant, and an analysis of the market for renewable energy sources and Marketing.

In the fourth chapter, we present raw materials and other supplies that the HPP needs.

In the sixth chapter there is a more exhaustive analysis of works capturing water security projects, water supply projects and electromechanical equipment available to the station of a hydropower plant.

The seventh chapter is an analysis of the organization of the establishment and general expenses. We present the way that we select HR and the job reward criteria.The seventh chapter discusses the impact of HRM policies and practices that will be implemented from the CEO of the plant and the strategic management case of hydroelectric in Karpenisi.

In the eighth chapter we make a description of the construction of the project and also provide technical and operational characteristics to estimate its contribution to the development of the river region. (location, space and environment facility) while analyzing the environmental and the socio-economic impacts that are caused while introducing measures to reduce and manage these risks.So it an attempt for a comprehensive and accurate assessment of hydropower projects.

In the ninth chapter we attempt to make a time scheduling of the investment program with gannt charts.

In the tenth chapter we perform an LCA for the SHP regarding three main materials ,aggregates, concrete, steel.

In the last chapter we try to estimate the cost of producing hydropower with 4 scenarios (by taking a loan or not, quantifying the environmental impact or not) and compare it with the cost of electricity from conventional sources.

Finally, the thesis concludes with a summary of the conclusions drawn from the analysis and synthesis of the data in the previous section.

Chapter 2 -Aim, description and significance of the project

In this thesis we attempted to analyze the current state of the penetration of hydroelectric projects in the energy system of the country. We gathered data that helped to assess the value of hydropower production and to analyze the contribution of the energy market.

Electricity generation from hydropower plants (HPPs) is for Greece, which has a rich geography and rich hydrodynamic,one promising solution to the energy problem. Greece's geography and climate provide a large potential for the further development of renewable energy sources (RES). According to the "2nd National Action Plan for the Abatement of CO^2 and other Greenhouse Gas Emissions 2000-2010" (NAPCC, 2002), currently under revision, the largest contributions are likely to originate from wind and solar energy, biomass for district heating and electricity generation as well as from small hydro installations.

The utilization of hydropower from HPP has specific environmental advantages over the use of conventional energy sources, because interventions into the environment is much smaller in size. Besides the environmental advantages, they also have many technical and socio-economic advantages.

The potential negative environmental effects, which vary depending on the characteristics of both the hydroelectric project and the region, in most cases assessed as moderate or small and reversible. This is achieved by using new technology and industrialized solutions using best practice and prevention, such as securing a permanent minimum flow downstream of the dam in the river bed, the construction of effective fish-ladders, placing fish-friendly turbines, construction of weirs at different heights, etc.

Therefore technological innovations have resulted in measures to address the negative impacts. Another solution to comprehensively address the environmental impact of HPP could be the implementation of an integrated environmental management system (EMS) system such as EMAS (Environmental Management Audit Scheme, the Environmental Management and Audit Scheme) that can be applied not only to achieve improved environmental performance of the company but also to increase economic benefits and to increase competitive advantage.

It is obvious that the HHP is an intriguing energy option to meet with minimal environmental impact. It is therefore necessary to encourage investments and to eliminate generally artificial barriers-that slow or inhibit the use cases in our country. With proper management of HHS is possible to further exploit the rich hydrodynamic country with a truly environmentally friendly.

Generally HPP ensure regulate voltage and frequency of the electrical system, optimize the production of thermal power and increase reliability. They say that a HHP is a multi-purpose project which is necessary in a Mediterranean country like Greece where rainfall is scarce and also has the ability to provide adequate mixing with other RES. (eg wind and solar).

Generally, HHP, except to make a significant contribution to regional development, security of energy supply as a domestic energy source, ensuring competitiveness of the economy nearly constant energy costs over the long term and sustainable development by reducing greenhouse gas emissions.

Finally, it should be noted that hydropower production, regardless of size, is an important tool to increase the participation of renewable energy sources in the world energy map.

Chapter 3- Analysis of the market for renewable energy sources and Marketing

3.1 - Introductory data for Renewable Energy Sources

Modern societies consume huge amounts of energy for heating ,transportation, electricity production and industrial use. Due to economic progress and a rising standard of living, the demand for energy is continually increasing. At present, the largest amount of energy we use is derived from conventional sources of energy which are petroleum, gasoline and coal. These are non renewable sources of energy which will be exhausted. The production and use of energy derived from these sources create a series of environmental problems, the most serious of which is the greenhouse effect.

On the other hand, renewable energy sources are continually renewed by the cycle of nature and are considered to be practically inexhaustible. The sun, wind, rivers, organic material are energy sources which are always available and are never exhausted. They are plentiful in our natural environment and they were the first sources of energy used by man until the beginning of the 20th century, when humankind turned to the intensive exploitation of coal and hydrocarbons.

Interest in the broader exploitation of RES, as well as in the development of reliable and economically profitable technologies to use their potential appeared, in the beginning, after the first oil crisis in 1979 and became permanent in the following decade after public awareness of global environmental problems. For many countries, RES are a significant domestic energy source, with great development potential on a local and national level. RES make an important contribution to their energy balance, helping to reduce dependence on expensive and imported petroleum and strengthening the security of their energy supply. At the same time, RES have a share to the protection of the environment because their use does not burden it due to the fact that they do not produce pollution or gases which increase the danger of climate change. It has also been established that the energy sector is mainly responsible for pollution of the environment, as nearly 95% of atmospheric pollution is due to the production, refining and use of conventional fuels.

Electricity consumption and power demand have significantly increased in Greece during the last decades, approaching the 48 TWh in 2000. In this context, the corresponding electricity consumption increase, in most Aegean Sea islands, has approximated 6% per annum for the 1990–2000 period.(Kaldellis,2002)

Greece has considerable RES potential which can provide a practical alternative solution to meeting its energy needs.

3.2 Types of renewable energy sources

In the last decades the electricity industry has experienced significant changes towards deregulation and competition with the aim of improving economic efficiency. At the same time electricity production technologies have been developed based on renewable resources (photovoltaic solar power, wind power, geothermal power, biomass and waste power) as an alternative to the use of conventional sources (coal, natural gas, oil), with the aim of reducing fuel consumption and pollution. (Vespucci et al,2010)

3.2.1 Wind Energy

Winds, defined as large air masses which move rapidly from one area to another, are created by the uneven heating of the Earth's surface by solar radiation. The kinetic energy of the winds is such that, with the current technology , mankind's electricity needs could be covered more than twice over.

The history of the use of wind energy is very old. Homer's tale about the trapping of the winds in Aeolus goatskin bag precisely indicates humans' need to have the wind at their disposal at a time and place convenient to them. For many hundreds of years, the movement of boats depended on the strength of the winds, while the usage of the windmill as a prime mover was abandoned only in the mid 20th century. It was the age when conventional fuels were expanding rapidly when electricity extended to even the most remote areas. The oil crisis at the beginning of the 1970's brought RES to prominence again. From that time , there has been a rapid development which has been reinforced by the urgent need to protect the environment. More and more people have come to realize that the wind is a clean and inexhaustible source of energy.

The modern systems for the use of wind energy are primarily machines which convert wind energy into electricity and are called wind turbines. The most economically important application for wind turbines is their connection to a country's electricity grid. In this case, a wind farm, i.e. a grouping of many wind turbines, is installed and operates in an area with high wind potential, and the entire production is transmitted to the electricity grid. Of course, wind turbines can function independently for electricity production in areas which are not connected to the grid, for mechanical energy for pumping, as well as heat. However, the power produced from applications of this type is limited and so is their economic importance.

3.2.2 Small Hydroelectric Projects

Hydraulic energy is a renewable and decentralized source of energy which has served and continues to serve mankind on the road to development. Water wheels, watermills, dristelles,fabric finishing mills, sawmills, spinning mills and other water driven machinery, even today, continue to use water power, making a significant contribution to the local economy of many areas in an entirely environmentally compatible way.

In many places throughout Greece, some small hydroelectric project plants continue to exploit water power to produce mechanical energy but also mainly for electricity production.

The use of the small hydro potential of thousands of SHP in the mountainous areas of Greece depends on the construction of decentralized which will stimulate local development and can simultaneously meet water supply, irrigation and other local needs.

The efficiency rates of water turbines are in some cases over 90% and the life of hydroelectric projects can last for more than 100 years.Both are two typical indicators of the energy efficiency and technological maturity of small hydroelectric plants.

Small hydro projects have significant advantages, such as the possibility of direct connection – disconnection to/from the grid or independent operation, their reliability, production of top quality electricity,their excellent performance over time, their long life, the predictable payback time on the required investments which is due to the very low costs of maintenance and operation and free raw material,environmental compatibility because they produce no emissions and their limited impact on the environment with the simultaneous coverage of other needs for water (water supply, irrigation, etc.).(Paish,2002)

By definition, a small hydroelectric plant is completely compatible with the environment and it can even contribute to the creation of small scale aquatic habitats along with small reservoirs. All of the various elements of the project can be harmoniously incorporated into the environment,using local materials in the traditional way and improving the surrounding area.

3.2.3 Biomass

Biomass includes any material derived from living organisms. More specifically, biomass for energy purposes includes any kind of material that can be used for the production of solid, liquid, and gas fuels.

There are two types of biomass: firstly, residue types (any kind of plant residues, animal wastes and the organic part of municipal waste) and secondly, biomass which is produced from dedicated energy crops.

The main applications for biomass fuel are:

- ✓ **Greenhouse heating:** In areas of Greece where there are large quantities of biomass available, biomass is used for greenhouse heating.
- ✓ **Heating buildings with biomass fuel in individual boilers**: In certain areas of Greece, individual/central boilers using olive pits are used to heat buildings.
- ✓ **Production of energy in agricultural industries**: Biomass for energy production is used by agricultural industries where biomass is produced in significant quantities as a residue or byproduct of the production process and which

have large heat requirements. Ginning mills, mills producing refined olive oil from the second pressing, rice mills, as well as small canning plants burn their residues to cover their heating needs and/or part of their electricity requirements.

✓ **Energy production in wood working industries:** Residues from woodworking industries are used for heat in their production processes as well as for heating their buildings.

✓ **District heating**: The heat is transported through a network of pipes from the station to the buildings to be heated.

✓ **Production of energy by sewage treatment plants and sanitary landfills**: The biogas produced by anaerobic digestion of liquid wastes in sewage treatment plants, or in sanitary landfills, is burned in internal combustion engines to produce electricity. At the same time, thermal energy from exhaust gas emissions and from the engine coolant medium can be used for the heating needs (e.g heating buildings).

3.2.4 Solar Energy

Solar energy is the energy derived from the sun through the form of solar radiation. Solar powered electrical generation relies on photovoltaic's and heat engines. A partial list of other solar applications includes space heating and cooling through solar architecture, day lighting, and solar hot water, solar cooking, and high temperature process heat for industrial purposes.

Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Active solar techniques include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air.

3.2.5 Biofuel

Bioethanol is an alcohol made by fermenting the sugar components of plant materials and it is made mostly from sugar and starch crops. With advanced technology being developed, cellulosic biomass, such as trees and grasses, are also used as feed stocks for ethanol production. Ethanol can be used as a fuel for vehicles in its pure form, but it is usually used as a gasoline additive to increase octane and improve vehicle emissions.

Biodiesel is made from vegetable oils, animal fats or recycled greases. Biodiesel can be used as a fuel for vehicles in its pure form, but it is usually used as a diesel additive to reduce levels of particulates, carbon monoxide, and hydrocarbons from diesel-powered vehicles. Biodiesel is produced from oils or fats using transesterification and is the most common biofuel in Europe.

3.2.6 Photovoltaics

Photovoltaic systems can also be implemented to provide cost-effective electricity in distant areas, while interconnected central stations could assist the micro isolated networks on the islands of the Aegean Sea. The market potential for PVs in Greece is mainly associated with stand-alone systems in remote areas for household and agricultural use. A substantial penetration of PV units in the energy system for the time horizon 2010 and 2015 is not expected. (Ministry for the environment,physical planning and public works,2006)

3.3 Advantages of renewable energy sources

The main advantages of RES are:

- They are practically inexhaustible sources of energy and contribute to reducing dependence on conventional energy resources.
- They are an answer to the energy problem for the stabilization of carbon dioxide emissions and other greenhouse gases. In addition,by replacing energy generation plants which use conventional resources,it leads to a reduction in the

emission of other pollutants, such as sulfur and nitrogen oxides which cause acid rain.

- They are domestic sources of energy and contribute to increasing energy independence and security of energy supply at the national level.
- They are geographically dispersed, leading to the decentralization of the energy system,making it possible for energy needs to be met at a local and regional level, thus relieving infrastructure systems and reducing losses from energy transmission.
- They provide opportunities for the rational use of energy sources because they cover a wide range of users' energy needs.
- They have low operating costs which are not influenced by fluctuations in the international economy and especially in prices for conventional fuels.
- RES investments create a significant number of new jobs, especially at the local level.

In many cases, they can be a catalyst for the renewal of economically and socially depressed areas and a magnet for local development through relevant investments .

3.4 Market analysis of electricity from renewable energy sources

This chapter analyzes the domestic market of electricity from RES. It provides data about production and consumption of electricity in Greece and analyzes the overall participation in the renewable energy production.

In particular the domestic market about RES is analyzed taking into consideration 3 factors:

a) The installed capacity (MW)

b) The produced electricity from RES (MWh)

c) The sale value of the electricity (€)

Finally we can see the share of market for 2011 of some of the most important companies of the sector.

3.5 Production and consumption of electricity-Participation rate of RES in Greece

According to Table 3.1,the total net electricity generation in Greece was 48,6 TWh in 2011 which increased by 4,1% compared with 2010.Lignite participates with the highest percentage,covering the 56,7% of the total sources in 2011.The natural gas came second with 30,5% and third the hydroelectric energy with 7,6%.

The rate of penetration of RES in the electricity production presented progressive course the last 5 years and reached 5,2% in 2011 from only 2,1% that it was in 2006.

Table 3.1: The Participation of various sources on the net electricity generation (2006-2011)

Year	Produced electricity	Lignite	Oil	Natural gas	Hydroelectric	RES
2006	50 TWh	53,8%	6,1%	18,8%	11,5%	2,1%
2007	52 TWh	55,1%	5,7%	23,7%	5,5%	2,3%
2008	51,3 TWh	52,5%	6,2%	23,4%	5,2%	2,8%
2009	48,5 TWh	63%	3,5%	19,4%	10,2%	3,9%
2010	46,7 TWh	58,8%	0,2%	22,2%	14,4%	4,4%
2011	48,6 TWh	56,7%	0%	30,5%	7,6%	5,2%

Source: ICAP,2011

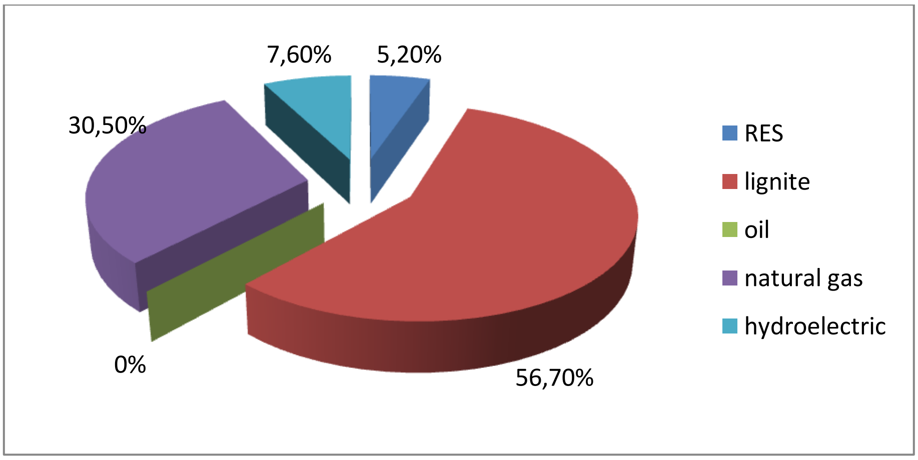


Figure 3.1: Proportionate share of the various energy sources in the net generation of energy
Source : ICAP,2011

The total imports of electricity in Greece amounted to 7,2 TWh in 2011 while in 2010 it was 15,7% higher.(Table 3.2) On the contrary the exports of electricity increased 40% and were 3,9 TWh in 2011. The total electricity demand formed in 51,9 TWh in 2011 slightly reduced in comparison with the previous year.Bulgaria, Albania , Italy ,Turkey and Fyrom are the only countries with which Greece carries out transactions of electricity.The biggest proportion of the imports of electricity was covered by Bulgaria in 2011 (39,3% of the total amount) and next came Turkey with 36,1% .On the other hand, Albania and Italy are the major countries that extract electricity from Greece. (53,8% and 43,4% respectively)

Table 3.2: Balance between electricity imports - exports per country (2010-2011)

Category	2010 (MWh)	2011 (MWh)
Total imports of electricity	8.517.364	7.179.773
Turkey	736.414	2.590.365
Albania	404.137	3.739
Fyrom	3.856.130	1.487.924
Bulgaria	3.453.732	2.823.515
Italy	66.951	274.230
Total exports of electricity	**2.811.233**	**3.947.444**
Turkey	38	178
Albania	490.706	2.124.579
Fyrom	8.068	108.598
Bulgaria	15	0
Italy	2.312.406	1.714.089
Balance between electricity import and export	**5.706.131**	**3.232.329**
Domestiel ectricity production	**46.659.646**	**48.639.959**
Total electricity consumption	**52.365.777**	**51.872.288**

Source: ICAP,2011

Table 3.3: Analysis of total electricity demand in the interconnected system per category (2011)

Category	Demand (MWh)	Variation 2011/10 %
Internal consumption	188.471	-6,62
Eligible customers	6.620.066	4,12
Distribution Network	42.426.947	-2,06
Pumping	380.151	-
Mines	967.738	1,56
System losses	1.288.914	-
Total electricity consumption (MWh)	**51.872.288**	**-0,94**

Source: ICAP,2011

3.6 Hydropower (<10MW)

Hydropower,we can say is another form of solar energy. Because of the solar radiation,the water evaporates and they move with the wind in the hinterland to replenish groundwater levels in the form of rain, snow etc. Then, through the aquifer the water bodies import within the terrestrial water bodies (rivers, lakes.) and they end to the sea. Because of the difference of the height between the starting point and the sea, the the potential energy of the water masses is converted into kinetic energy in the form of a stream.

Hydropower is the energy that is produced from the operation of either kinetic or dynamic energy of water masses moving in terrestrial aquatic systems. The advantage of this takes the form of electricity generation through the operation of electrical generators.

Based on the power of the hydroelectric station we usually have 4 categories:

- hydro (> 10MW)
- small hydro (<10MW)
- mini hydro (<500kW) and
- pico hydro (<100 kW).

However the most rapidly growing technique is that of a “Small Hydroelectric "power up to 10 MW, which are installed in relatively small streams and have limited impact on the environment as they involve just an abstraction, a conduit under pressure and the hydraulic turbine. The hydroelectric power plants <10 MW do not require extensive construction and, mostly, someone can harness the potential energy from the falling water masses due to the difference in altitude they fall .In addition small hydroelectric power stations are usually correlated with private investments.

The small-scale hydropower projects differ significantly from large scale in terms of their impact on the environment. The large hydroelectric plants require the creation of dams and huge reservoirs with significant impact on the environment.The building dams restricts the movement of fish, wildlife and affect the entire ecosystem.

On the other hand ,small-scale hydropower usually are installed near rivers or canals and their function shows a smaller nuisance.When a small hydroelectric plant operates, part of the flow of a river is led to the turbine to produce mechanical energy and hence electricity through a generator.The used water then returns to the natural reservoir following the natural flow.

When using appropriate designs and local manufacture, micro scale hydro-electric projects can compete with large hydro projects in economic terms (Brown, et al., 1988).

Basic importance to both the profitability of the investment and the impact on environment,is the appropriate choice of the location and the design of the whole project.

3.6.1 The contribution of small hydro power stations to the electricity generation in Greece

Hydropower is still the most widely used RES worldwide (Paish, 2002; Frey and Linke, 2002), contributing almost with 18.5% to the fulfillment of the planet electricity generation (IEA, 2006; Department of Energy and United Stated of America (DOE), 2006). Although there is a strong opposition (Kaldellis and Vlachou, 2002) of local communities towards new hydro power stations claiming important environmental impacts, small hydro power stations remain an attractive opportunity for further utilization of the available hydro potential throughout Europe.

SHP stations constitute energy production installations with less environmental impacts, since they utilize local water resources without the need of extended infrastructure facilities and the construction of huge dams.

According to the existing international literature (Fritz, 1984; International Hydropower Association- Canadian Hydropower Association (IHA), 2000), "the rated power of a SHP station is usually less than 10MW, while all stations with rated power less than 1MW are characterized as mini." For very small applications (less than 50 kW) one may also use the expression ''micro hydro power station''.

In 2001, 15 LHP stations operate in Greece with a total rated power slightly above 3000MW. (Kaldellis and Vlachou, 2002)

Greek electricity generation is based mainly on locally extracted low quality lignite as well as on imported natural gas and heavy polluting oil, used mainly in autonomous island power stations (Kaldellis et al., 2004, 2005a). Greece and, more precisely, the west part of the mainland, possesses a significant hydro-power potential which has been up to now only partially exploited (Kaldellis and Vlachou, 2002; EC, 1999). The ground morphology in combination with the high precipitation facilitates the application of similar power stations (Korbakis and Kaldellis, 2001).

The first SHP station operating in Greece since 1927 is the one of Glafkos (1.6MW) located in N. Peloponnesus (Papantonis, 2001), while the SHP station of Vermio (1.8MW) has been also erected in central Macedonia almost during the same period (1929). Up to 1994, only eight SHP stationsM had been operating with a total rated power equal to 42.8MW. After the application of the 2244/94 law permitting the installation of power stations based on RES by private investors (Kaldellis, 2001) had been expressed.

SHP installations are a financial attractive and an environmental friendly solution, able to contribute remarkably to the solution of the energy demand problem of Greece.

Properly designed SHP plants should lead to considerable profits replacing heavy polluting lignite and imported oil

3.6.2 Advantages of hydropower

The main advantages of hydropower from units of small and large scale are:

1. Hydropower plants can be put into operation immediately just claimed
2. It is a "clean" and renewable energy source
3. Through water supplies were given the opportunity to meet and other needs, such as water supply, irrigation, halting streams, creating wetlands, recreational areas and sports

This study will focus on a small hydro station.

3.7 Operation mode

The conversion of water power using hydro projects (water supplies, dam, closed chute, water turbine, generator) produces hydroelectricity. Hydropower plants exploit the natural cycle process of water .The operation of the hydropower units is based on the difference in height between the head entry and exit points while it moves.

When the water passes the pipeline it moves a turbine which activates the generator. The amount of electricity generated is determined by several factors. Two of the most important are the **volume of the water** flowing and the **head height** difference between the free surface of the reservoir and the turbine. The amount of electricity produced is proportional to these two sizes. Therefore, the generated electricity depends on the amount of water of the reservoir. For this reason only in areas with significant rainfall, rich sources and appropriate geological formation hydropower projects can be constructed.

In Greece, hydropower meets approximately 9% of our energy electricity needs.

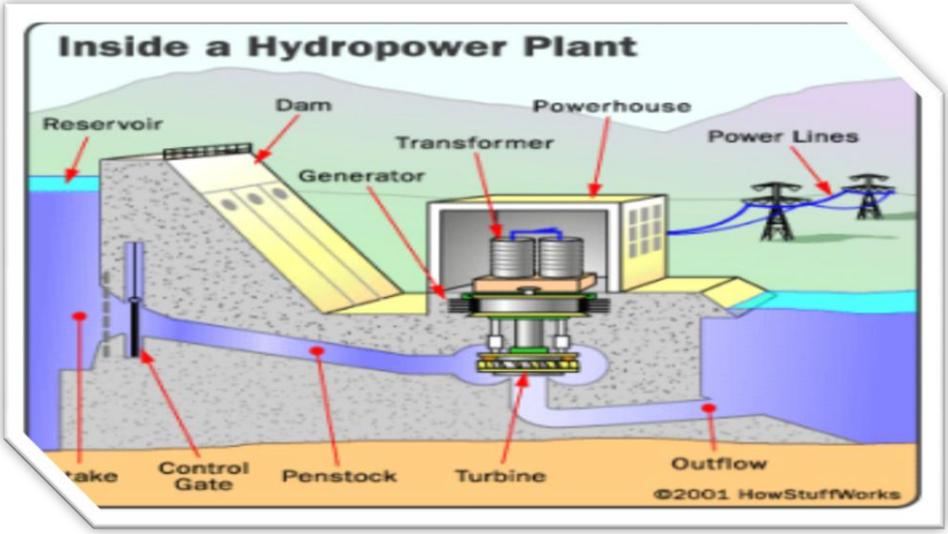


Figure 3.2: Model of Production Installation of a Micro-Hydro Power
Source: www.google.com

The availability and levels of exploitation of hydro energy are determined by the prevailing climatic conditions, which determine the temporal volume of water masses in the terrestrial aquatic system where the hydropower plant is installed.

The installation and operation of a hydroelectric power plants <10 MW is characterized by an extremely low level of flexibility because of the location of the power plant .This low level is formed due to the fact that the choice of the installation must be an appropriate combination of available suitable topography and land water system.

The environmental intervention in terms of hydropower exploitation is a major issue in terms of the broader social acceptance .By saying environmental intervention we mean the effect they have on the various ecosystem installation and operation. When we have to deal with hydropower plants with capacity less than that 10 MW, these environmental intervention are limited because of the limited work necessary installation they need.

3.8 Operating entities of electricity market in Greece

3.8.1 Regulatory Authority for Energy (RAE)

The Regulatory Authority for Energy (RAE) is an independent administrative authority and was established on the basis of the provisions of **L. 2773/1999**, which was issued within the framework of the harmonization of the Hellenic Law to the provisions of **Directive 96/92/EC** for the liberalization of the electricity market.

New competences and duties were assigned to RAE with respect to electricity and natural gas sectors by the Electricity Law 3426/2005 and the Gas Law 3428/2005, in alignment with the relevant provisions of the EC Directives 2003/54 and 2003/55, in particular with respect to access tariffs to electricity and gas networks, the terms and conditions for the provision of balancing services in natural gas, as well as on issues related to security of electricity and natural gas supply.

Some of the main duties and responsibilities assigned to RAE are:

- ✓ Monitoring the operation of all sectors of the energy market (Electricity, Natural Gas, Oil Products, Renewable Energy Sources, etc.).
- ✓ Collecting and processing all the information from companies in the energy sector while respecting the principles of confidentiality.
- ✓ Participate in the pre-parliamentary legislative process through recommendation to the Minister of Development of the appropriate measures related to compliance with competition rules and to the overall protection of the consumers in the energy market.
- ✓ Advice under the form of a simple opinion, with respect to the enactment of the secondary legislation, with the exception of the Electricity Grid Operation Code, the Power Exchanges Code, the Distribution Network Operation Code, where RAE enjoys the right of a consenting opinion.
- ✓ Cooperate with Regulatory Authorities of other countries, international Organizations and the European Commission.

3.8.2 Independent Power Transmission Operator (IPTO or Independent Transmission Operators for Electricity) S.A.- The functioning of the electricity market (LAGIE SA)

The Independent Power Transmission Operator (IPTO or Independent Transmission Operators for Electricity) S.A. was established in compliance with Law 4001/2011 and European Union Directive 2009/72/EC regarding the adoption of common rules in the organization of EU electricity markets.

According to Law 4001/2011 Independent Transmission Operators for Electricity undertakes the role of Transmission System Operator for the Hellenic Electricity Transmission System and as such performs the duties of System operation maintenance and development so as to ensure Greece's electricity supply in a safe, efficient and reliable way.

According to Law 4001/2011, Independent Transmission Operators for Electricity undertakes the role of Transmission System Operator for the Hellenic Electricity Transmission System under which Independent Transmission Operators for Electricity performs all duties of Transmission System operation, maintenance and development that were previously assigned to the Hellenic Transmission System Operator (HTSO) and PPC's Transmission Basic Unit(BU) as the System owner.

To that effect, the transmission-related organizational units of the above organizations are integrated into Independent Transmission Operators for Electricity via the transfer of all relevant organizational functions, personnel and Transmission System assets. In addition, under Law 4001/2011 all relevant rights and obligations of the above transmission related organizational units are transferred to Independent Transmission Operators for Electricity under universal succession.(ICAP 2011)

From 1 February 2012 after modulation of the transport of PPC and the contribution of industry to the Directorate General Transport Company SA ITSO (according to law

N.4001/2011) and the completion of the spin-off of the Hellenic Transmission System Operator and its contribution to the ITSO SA the below are valid:

1. The ITSO SA is the new manager of the System and succeeds HTSO activities relating to the operation, maintenance and development of the System
2. The functioning of the electricity market, Power Market Participation SA, now perform what activities where managed by the Hellenic Transmission System Operator apart from those which are transferred to the ITSO SA according to the Article 99 of Law 4001/2011
3. Power Market Participation SA applies the rules for the operation of the electricity market .

3.8.3 CRES (Centre for renewable energy sources and savings)

The Centre for Renewable Energy Sources and Saving is the Greek national entity for the promotion of renewable energy sources, rational use of energy and energy conservation.

CRES is dynamically active, in the frame of the national and Community policy and legislation, for the protection of the environment and sustainable development.

The establishment of the Centre for Renewable Energy Sources was provided by Article 25 of Law 1514/1985 "Development of scientific and technological research" (Official Gazette A 13) and implemented by Presidential Decree 375/1987 "Establishment of a private legal entity under the name Centre for Renewable Energy Sources" (Gov. A'-167).

The purpose of the Center is to promote renewable energy, energy saving and rational use of energy, as well as any kind of support activities in these areas.

Furthermore, Law 2244/94 "Adjusting issues of power from Renewable Energy Sources" and the recent law 3851/2010 RAE has decisive authority for the licensing of renewable energy. It is responsible to monitor to ensure third party access to the country, the operation of the interconnector trade imports and exports, as well as checking that the electricity market-TSO-operates smoothly.

On the same basis, CRES advise on licenses for the supply of electricity and monitors the development and maintenance of fair competition rules and consumer protection, in cooperation with competent bodies and finlly may initiate proceedings to impose penalties, if found that the specific provisions are violated.

The sector of Renewable Energy Sources is a dynamically developing part of the global energy policy. Electricity production from RES is one of the major growth centers of industry and especially the field of wind energy has a leading role.

Each individual unit of electricity produced from RES is an independent legal entity, which is a subsidiary company of each business entity that operates at the production of electricity from RES.

Renewable energy is the energy that is created from natural resources such as sunlight, wind, hydro and geothermal energy, which may be renewed naturally and at the same rate at which they are used. Similarly, "new" technologies of renewable energy sources include biofuels, hydropower, biomass and solar and wind energy.

Climate change, due to the aggravation of the greenhouse effect, and the continuous increase of oil prices have led the international community to increase its interest in renewables. Therefore, in recent years has been promoted a series of incentives and laws for better penetration of RES in international markets. This, apart from the production of "clean" energy has multiple benefits such as increased flexibility of electrical systems, creating jobs,increasing alternatives to energy sources and reduce dependence on imported fossil fuels.

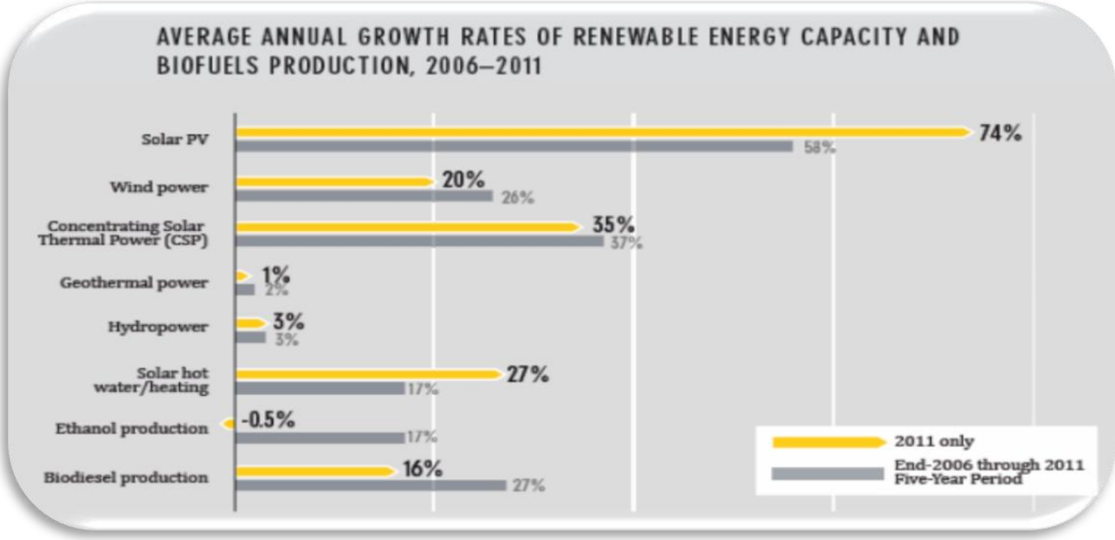


Figure 3.3: Average annual growth rates of installed capacity of RES projects
Source: Renewables 2011- Global Status Report – 2011

3.9 RES in Greece

The total installed capacity of RES rose in the period 2002-2010 with a rate of 20.3%. Wind farmas maintain the dominance of the capacity of RES in Greece (78%), then follow the micro-hydro plants (12%) , the solar Parks (7.4%) and the Biomass plants (2, 4%). Under the target set for Greece in 2020, wind energy should account for 72% of the installed power of RES projects.

The use of RES in Greece increased significantly over the last 10 years and this is mainly due to the gradual harmonization of Greek legislation with EU directives .DEI had the monopoly of electricity power by 1994 with an installed capacity of RES approximately 70 MW .The substantial liberalization of the energy market was in 1999 by Law 2773/99 and the simultaneous establishment of the Regulatory Authority for Energy (RAE) and the National Transmission System Operator (TSO) .In Greece the fast development of RES began by Law 2773/99 in 2001. For example the indicative rated power of RES in Greece increased from 351 MW in 2001 to 1040 MW in 2007.

In 2001, in line with EU Directive 2001/77/EC, Greece set the target of 20.1% of renewables in electricity generation by 2010 .This would correspond to about 3000 MW of installed capacity consisting mainly of wind power plants (2500 MW) .Nevertheless, at the end of 2010 the installed capacity of RES in Greece was equal to 1736 MW.

Important legislation on RES was the Law 3468/2006, for the production of electricity from RES, with which Greece is fully in line with EU to replace conventional energy sources. The law provided subsidies for all renewable ,strong investment incentives and simplified permitting procedures .

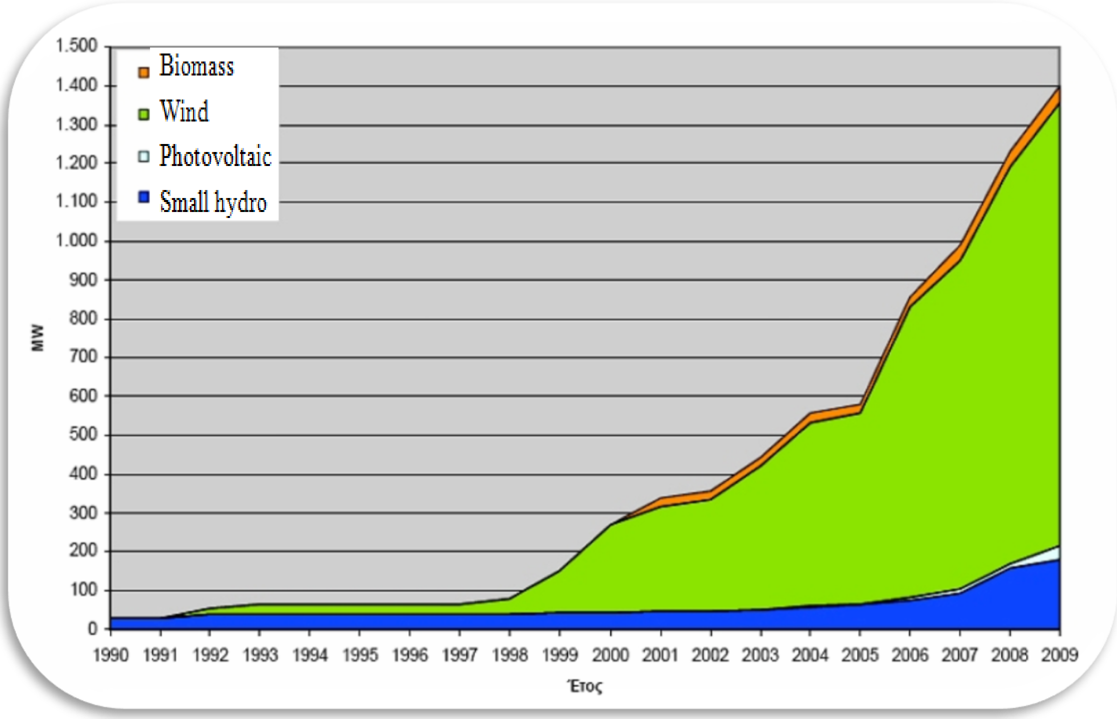


Figure 3.4: Installed capacity of RES 1990-2009
Source: Ministry of Environment, 2010

The most recent legislation in relation to RES is N.3851/2010 which accelerates the development of renewable energy and gives major attention for climate protection through the promotion of electricity generation .The law also aims to minimize the permission time .

It is commonly accepted that the development of RES in Greece could be faster. The main reasons for delay are political, social, technical and economic .

Specifically, the licensing process is still lengthy, and because many actors involve in the procedure ,the progress of licensing is considerably delayed. There are also cases where the national grid is not sufficient for the development of additional RES. Finally, issues of location and social reactions have also delayed a large number of projects.

These problems have not been alleviated, despite the implementation of the Special Spatial Plan for renewable by 2008.

In 2007, European Union leaders agreed a so-called "20-20-20", namely the reduction of greenhouse gas emissions to 20% while increasing the use of renewable energy to 20%, from 6.5% today, the total energy production by 2020.(Ramos H M, Mello M, 2008, Annual Costs and Charges Manual distribution network actively let the year 2011)

3.10 State for authorization evolution of RES - Ability power absorbed by the existing network

By the end of 2011 ,the total production licenses for RES projects were up to 25.269 MW while in December 2010 there was 45% less, from which 80% of all were covered from wind farms (20.093 MW),and then followed the photovoltaic plants with 11,8% (2.990 MW).

What is not acceptable is that the licenses for RES in September of 2011 were up to 78.442MW and only 1/3 of the total number was given.

Particularly for photovoltaic’s, the number of applications in the first 9 months of 2011 to connect to PPC amounted to approximately 18,000 and covered a total of 4.000 MW. In January of 2012 the photovoltaic amounted to 98.361,6 kW and the number of activations reached up to 11,201.

Table 3.4: Power distribution of RES projects with final connection offer per region and Technology (January 2012)

District /technology	Wind farms	Small hydroelectric station	Combined Heat and High Performance	Photovoltaic's	Biomass-Biofuels	Total
Central Greece	1.544,5	12,8	0	117,1	0	1.674,2
Peloponnese	534,2	1	0	238,5	5	778,4
western Macedonia	436,4	50,3	0	64,4	0	551,0
Western Greece	257,4	13,3	0	149,2	6,4	426,3
Thessaly	237,6	21,6	0	131,7	0	390,9
Central Macedonia	166,1	26,2	11,6	153,8	6,7	364,2
East Macedonia and Thrace	115,2	5,7	9,5	117,3	7,6	255,2
Attica	175,2	0	4,2	18	0	197,9
South Aegean	128,6	0	0	0	0	128,6
Epirus	52,2	9,6	0	41,9	1,6	105,4
Ionian Islands	69,7	0	0	0	0	69,7
Total	3.717,6	140,5	25,3	1.031,9	27,3	4.941,8

Source: ICAP,2011

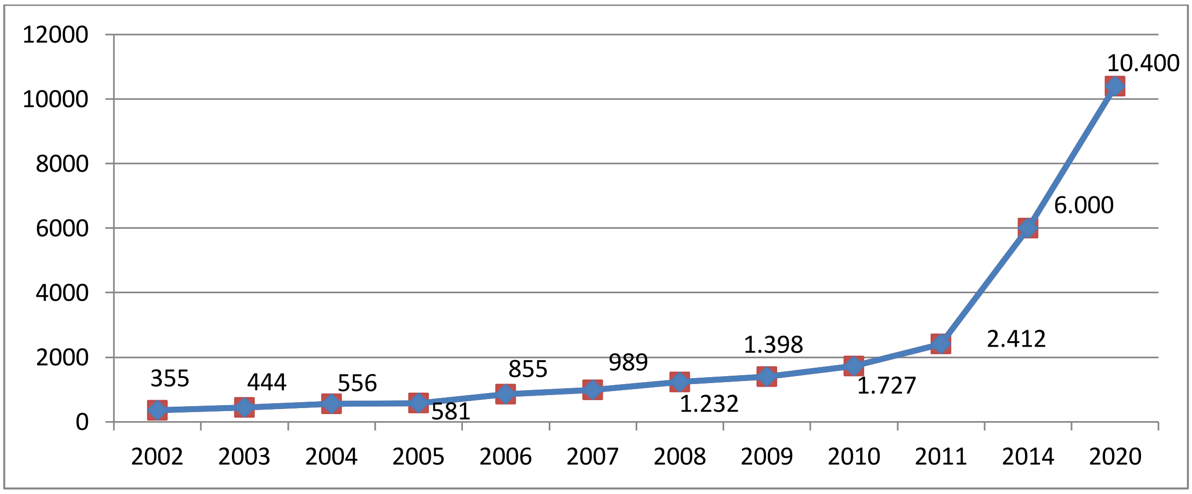


Figure 3.5: Diachronically development of RES installed capacity
Source: ICAP 2011

The total installed capacity of power plants using RES in Greece recorded an average annual growth rate of 23.7% during the period 2002-2011 .Photovoltaics made the largest annual increase in 2011 (173.3%).Then followed the small hydroelectric power stations (8.5%). Much of the power belongs to the Interconnected System with 2.052 MW in 2011 .Diagrams show the power distribution depending on the region and technology.

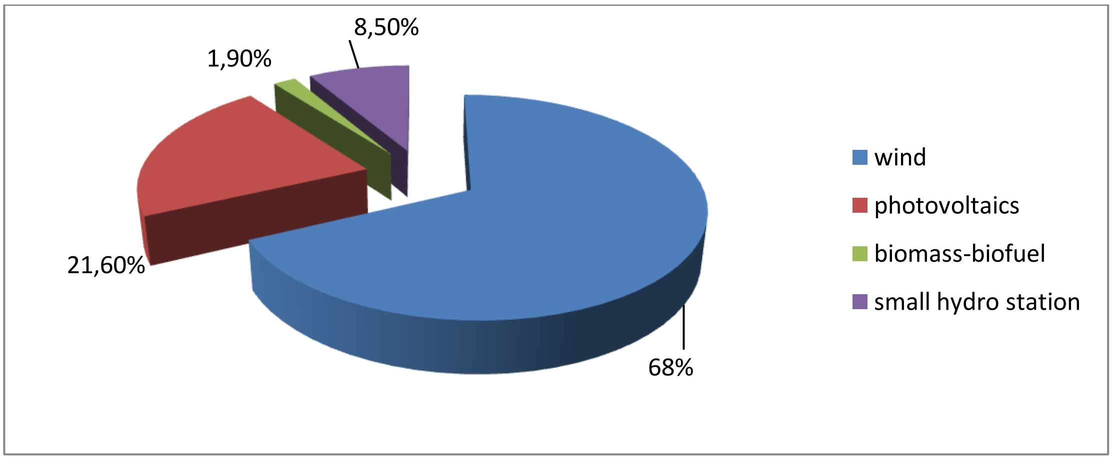


Figure 3.6: Participation of the various forms of the total installed capacity of RES (2011)
Source: ICAP 2011

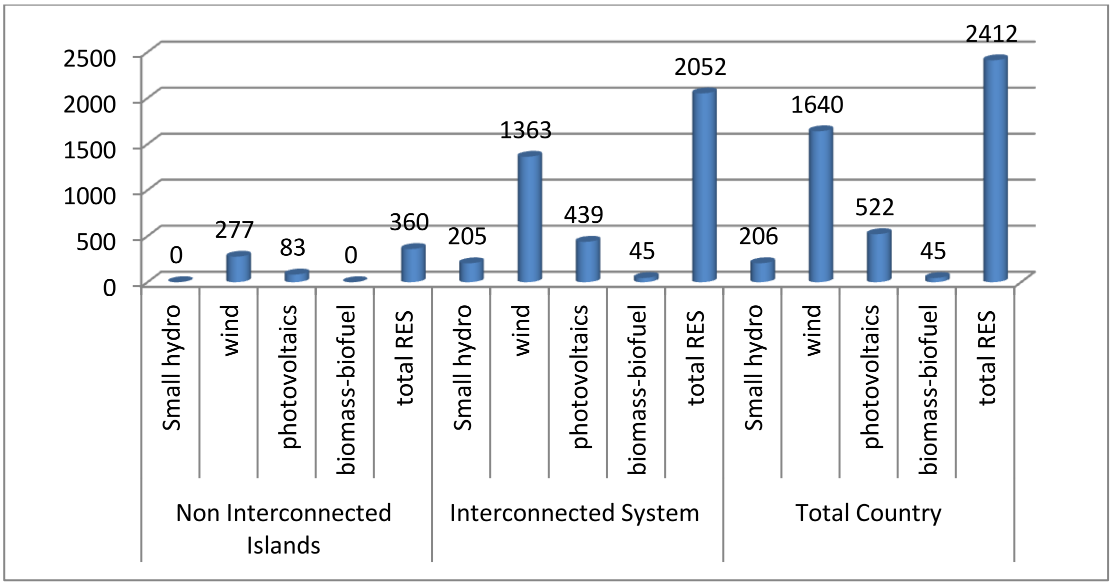


Figure 3.7: Distribution of the total capacity of renewable energy (MW) in the Interconnected System and the Non Interconnected Islands by Technology (2011)
Source: ICAP 2011

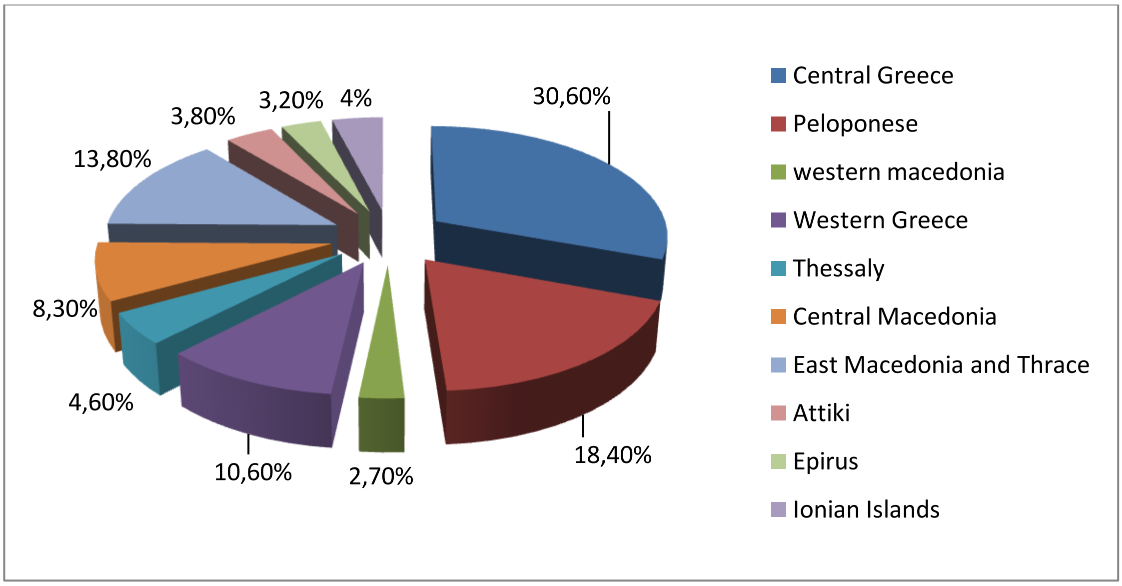


Figure 3.8: Distribution of the total capacity of renewable energy in the Interconnected System by Administrative Region (2012)
Source: ICAP 2011

Table 3.5: Electricity generation from RES per technology (2006-2011)

Year	Wind (MWh)	Photovoltaic's (MWh)	Small hydro (MWh)	Biomass-Biofuel (MWh)	Total (MWh)	Variation
2006	1.682.677	291	220.839	91.937	1.995.743	-
2007	1.872.989	699	223.616	155.901	2.253.206	12,9%
2008	2.241.898	5.707	325.746	176.696	2.750.046	22,1%
2009	2.547.260	46.469	657.888	181.893	3.433.511	24,9%
2010	2.713.937	157.788	753.944	193.933	3.819.602	11,2%
2011	3.315.227	555.690	581.430	199.102	4.651.448	21,8%

Source: ICAP 2011

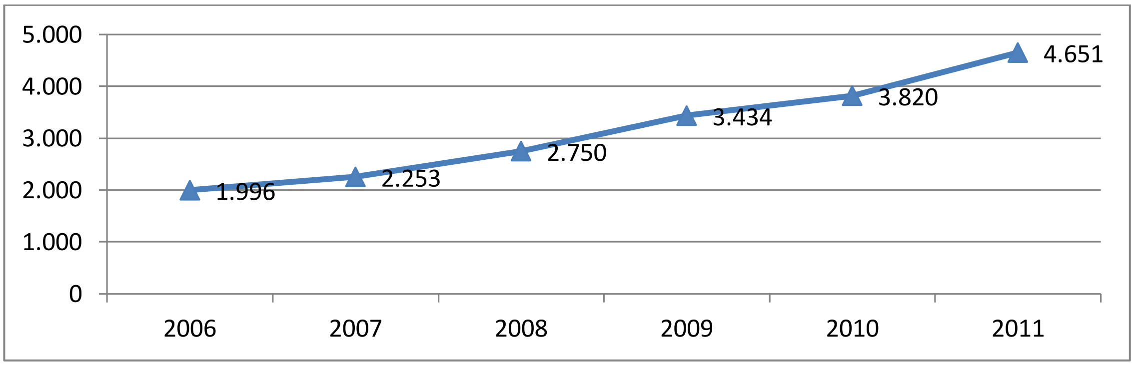


Figure 3.9: Evolution of the total produced electricity in GWh of electricity (2006-2011)
Source: ICAP 2011

3.11 Sales value of electricity from RES

The following tables present the evolution of the value of electricity produced from RES for the period 2006-2011 .These sales experienced tremendous growth in recent years with an average annual rate of 33.9% and amounted to 639.5 million euro in 2011. Specifically, the largest increase occurred in 2011 mainly due to the development of photovoltaic power plants in which corresponding respectively the highest selling price per unit of energy which was produced.

Table 3.5: Value of total sales of electricity from renewable in the interconnected system and the non-interconnected islands (2006-2011)

Year	Interconnected system	Non-interconnected islands	Total	Variation
2006	107,86	40,94	148,8	-
2007	142,01	47,42	189,43	27,3%
2008	178,24	53,59	231,83	22,4%
2009	272,25	64,14	336,44	45,1%
2010	335,01	77,8	412,81	22,7%
2011	511,03	128,48	639,51	54,9%

Source : ICAP 2011

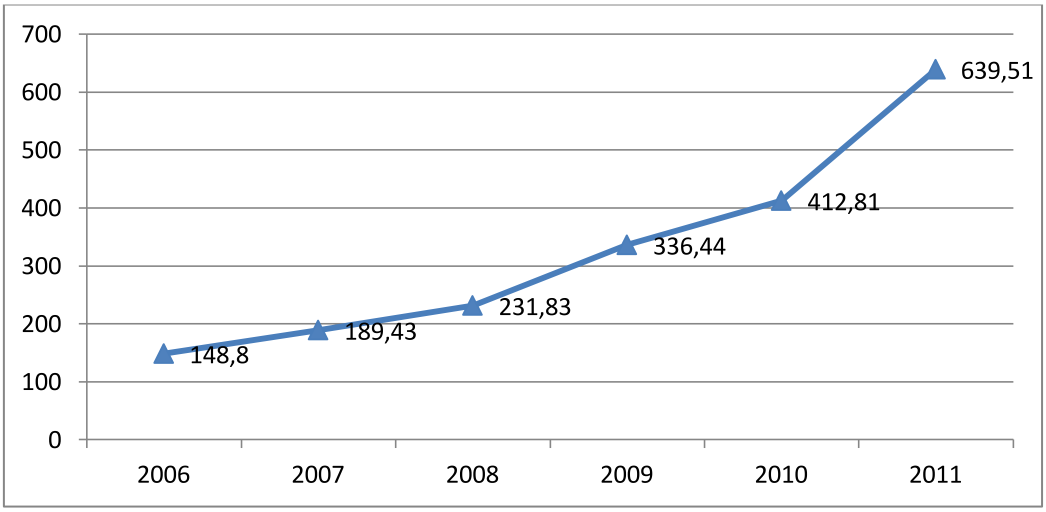


Figure 3.10: Evolution value of electricity produced from RES (2006-2011)

Source: ICAP 2009

The domestic production of renewable energy is expected to continue its upward trend and the period 2012 -2020. According to a study by the National Technical University estimated production would increase about 23,7 TWh in 2020 .So the estimated value of the energy provided will be 2.96 billion euro in 2020.

Table 3.6: Prediction of development of production in GWh electricity from RES and CHP by technology (2012 -2020)

Tecnology	2012	2013	2014	2015	2016	2017	2018	2019	2020
Wind	5.435	7.242	9.072	10.303	11.093	12.219	13.534	15.556	16.800
Photovoltaics	723	1.039	1.354	1.670	1.915	2.159	2.404	2.648	2.893
Small Hydro	950	1.052	1.155	1.187	1.219	1.251	1.283	1.315	1.347
Biomass	261	281	453	504	671	916	941	1.071	1.234
Combined Heat and High Performance	390	390	450	450	510	570	630	690	750
Solar	0	0	86	86	212	337	463	589	715
Sum	7.759	10.004	12.570	14.200	15.620	17.452	19.255	21.869	23.739

Source: NTU study , 2011

Table 3.7: Prediction of development of total sales (payments to producers) of electricity from RES and CHP by technology (2012 -2020)

Tecnology	2012	2013	2014	2015	2016	2017	2018	2019	2020
Wind	524	719	917	1.051	1.136	1.258	1.400	1.619	1.754
Photovoltaics	251	352	417	478	506	531	556	582	608
Small Hydro	85	96	107	110	114	117	120	124	127
Biomass	40	43	73	82	111	153	157	179	208
Combined Heat and High Performance	35	35	42	42	48	55	61	68	74
Solar	0	0	0	23	56	89	123	156	189
Sum	935	1.245	1.556	1.786	1.971	2.203	2.417	2.728	2.960

Source: NTU , 2011

3.12 Market Shares of Companies in electricity production from RES

In the sector of RAE the most developed sector is that of wind energy and specifically represents 68% of the installed capacity. The tables below represent certain undertakings of installed capacity of power plants from renewable sources by 2011 and market shares of companies in the industry in 2010 based on electricity sales and share estimates for 2011.

Finally ,we can mention a slight decline due to an increase in the value of the electricity that is produced by photovoltaic plants and this has resulted in an overall increase in the total amount of electricity produced from renewable energy sources and the reduction of the shares of the groups involved in the RES industry .

Table 3.8: Shares of companies on the basis of installed capacity (2011)

Companies	Shares
EDF Group	11,5%
Terna Energy	11%
Group companies Ch.Rokas	10,5%
Enel green power	8%
Group companies Ellaktor	7,5%
PPC Renewables SA	6%
Group RF Energy	2,5%-3%
Eunice Group	2,5%
Protergia SA /Mytilineos Group	1,5%-2%
Acciona Energy	1,8%
RE Services EPE (Windpower)	1,7%
Enercon Hellas	1,1%
Crete Hellas Holdings (IWECO)	1,1%
BCI	1%
Jasper WIND	1%
Gkamesa wind	1%
Private power corporation SA	1%
Envitec SA	1%

Source: ICAP GROUP,2011

Table 3.9: Shares of companies based on value of electricity sales (2010-2011)

Companies	2010	2011
Group companies Ch.Rokas	11,5%	7,5%
EDF Group	8,5%	7%
Terna Energy	8%	7%
PPC Renewables SA	7,5%	5%
Enel green power	5,5%	4,5%
Group companies Ellaktor	5%	4%
Gkamesa wind	5%	3,5%
Protergia SA /Mytilineos Group	4%	3%
Acciona Energy	2%-2,5%	1,5%-2%
Eunice Group	1,5%-2%	1,5%
Enercon Hellas	1,5%-2%	1%-1,5%
RE Services r EPE (Windpower)	1,5%-2%	1%
RF Group ENERGY	1%-1,5%	1%
Technical energy SA	1,5%	1%
CreteHellas Holdings IWECO)	1,5%	1%
Jasper Wind	1,5%	1%
BCI	1%	0,5%-1%
Envitec SA	1%	1,5%

Source: ICAP GROUP,2011

3.13 Conclusions

- The penetration of RES in total electricity production showed an upward course in the last five years and reached 5.2% in 2011
- The total installed capacity of power plants from RES increased at an average annual rate of 23.7% between 2002-2011 and amounted to 2.412 MW in 2011.Wind holds 68% and the small hydroelectric stations came third.
- The total produced electricity increased from 2006 to 2011 at an average annual rate of 18% and amounted to 4.651 GWh in 2011.
- Total sales of electricity from RES showed a striking increase in the period 2006-2011 with an average annual rate of 33.9% and amounted to 639.5 million euro in 2011. Sales of small hydropower plants received 8%.

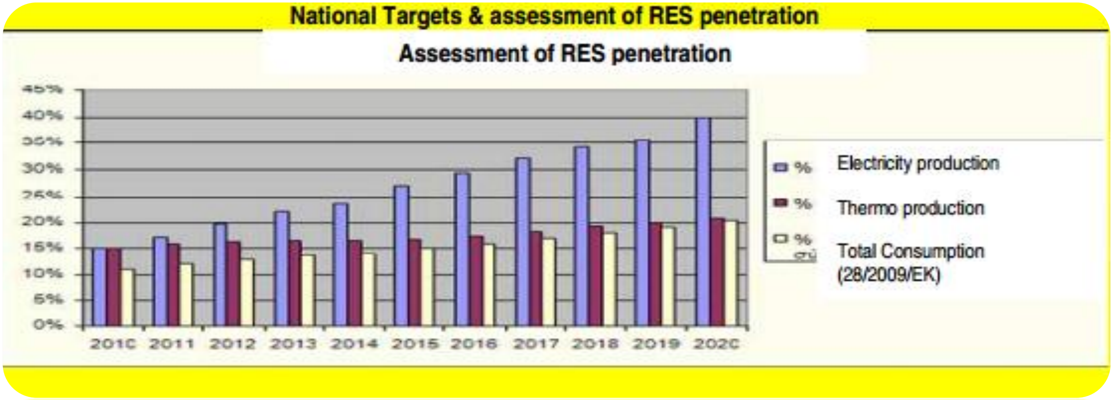


Figure 3.11:National Targets and assessment of RES penetration

Source: Ministry of environment energy and climate change,2009

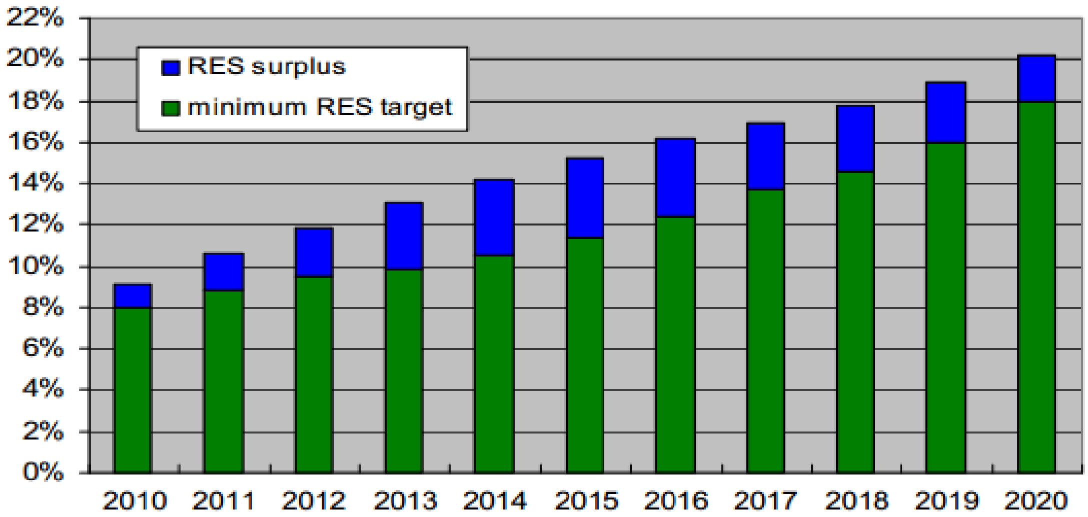


Figure 3.12:Trajectory of RES in gross final energy consumption until 2020.

Source: Ministry of environment energy and climate change,2009

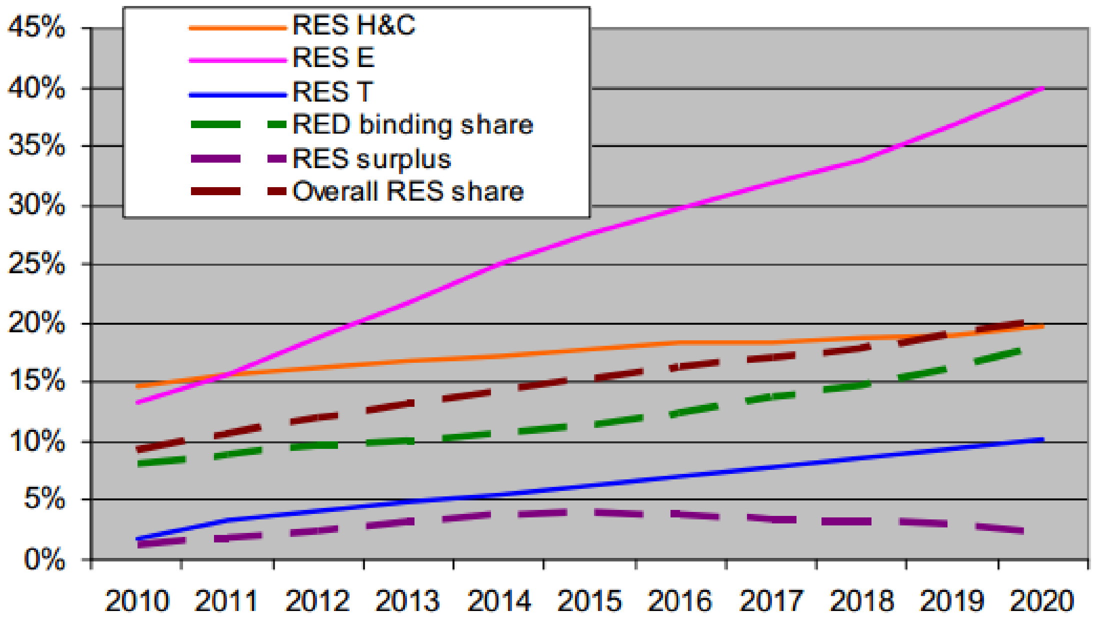


Figure 3.13: Projections of the share projection of RES in the final consumption of the three main sectors (electricity, heat & cooling, transport) and the overall share of RES as well as the expected surplus in gross final energy consumption to 2020

Source: Ministry of environment energy and climate change,2009

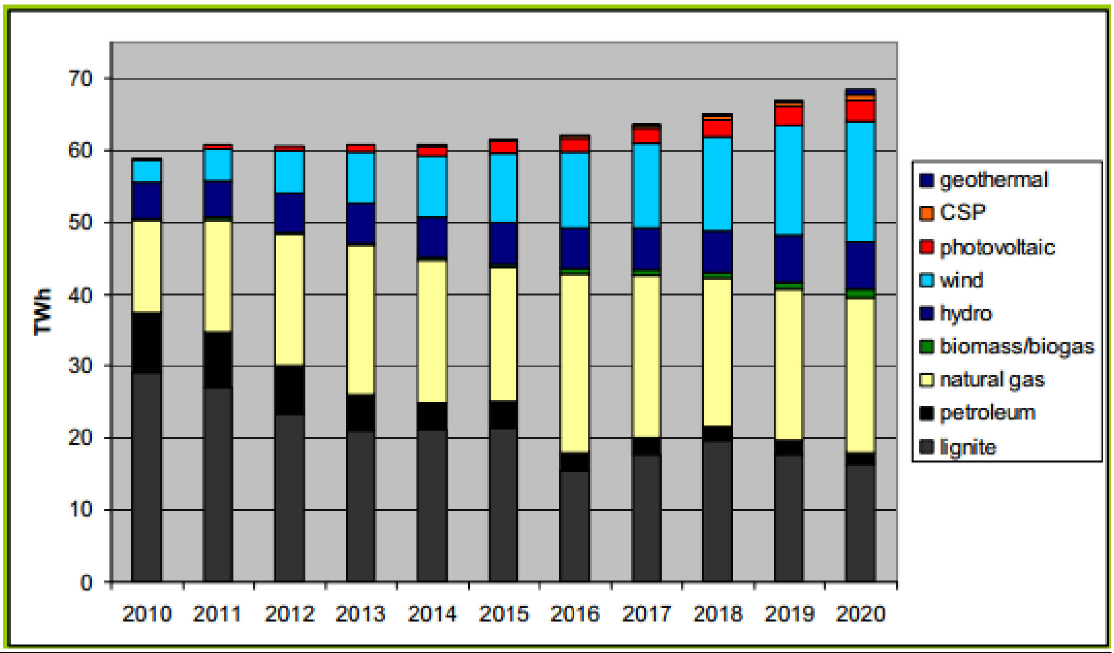


Figure 3.14: Estimated electricity generation from the different technologies/fuels to 2020

Source: Ministry of environment energy and climate change,2009

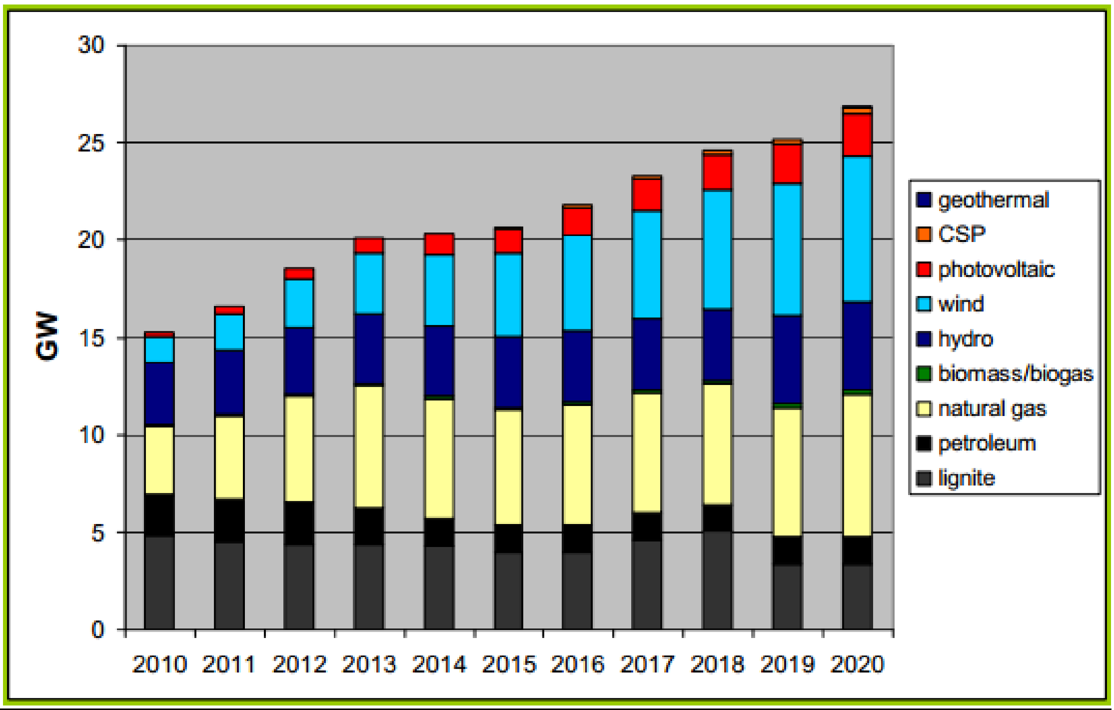


Figure 3.15: Estimated installed capacity of the different RES technologies for electricity.

Source: Chaviaropoulos

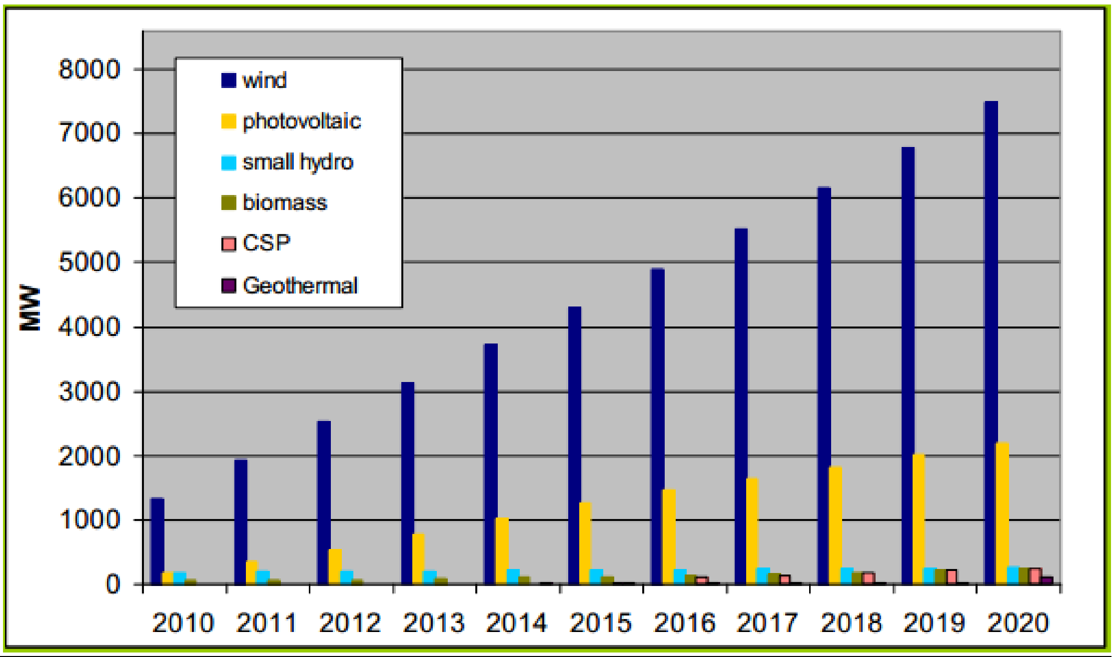


Figure 3.16: Estimated installed capacity from the different RES technologies/fuels to 2020.

Source: Chaviaropoulos

STATUS OF RES Investments in Greece (June 2011)															
TECHNOLOGY	POWER			Application for Production Licence		Production Licence		Connection Offer		Installation Permit		With PPA		In Operation	
				end 2010	June 2011	end 2010	June 2011	end 2010	June 2011	end 2010	June 2011	end 2010	June 2011	end 2010	June 2011
Wind	MW			61791,0	65395,1	14373,4	18432,4	3601,5	3320,2	1249,2	1460,6	360,3	272,5	1297,7	1431,6
Biomass	MW			1461,9	1517,6	243,4	361,9	42,3	51,0	21,2	24,4	0,8	5,5	44,0	43,5
Geothermal	MW			340,5	340,5	8,0	8,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Small Hydro	MW			2220,9	2255,7	886,3	931,4	189,3	161,5	79,2	66,5	28,0	22,5	196,3	205,6
Solar PV	MW			4255,0	5387,3	1564,6	1947,0	524,9	2557,2	320,2	348,5	497,4	1048,0	198,3	341,1
CSP	MW			963,2	1013,8	0,0	320,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Hybrid	MW			1742,8	1828,7	262,8	382,3	0,0	0,0	0,1	0,1	0,0	0,0	0,0	0,0
	Total MW			72775,3	77738,7	17338,5	22383,4	4358,0	6089,9	1669,9	1900,1	886,5	1348,5	1736,3	2022,2

Figure 3.17: 2011 Developments

Source: Chaviaropoulos

3.14 Legal framework for the production of electricity from RES

3.14.1 Legal framework at an International Level

3.14.1.1. The Kyoto protocol

The Kyoto Protocol was a necessary step against climate change and it entered into force on 16 February 2005, following the signing by Russia.

The Kyoto Protocol:

- Applies the Convention UN Framework on Climate Change (UNFCCC).
- It sets binding targets for reductions in greenhouse gas emissions about 5% below 1990 levels between 2008-2012.
- Ratified a total of 168 States to date whose emissions account for approximately 61.6% of total emissions of carbon dioxide.
- The industrialized countries commit to reduce, over the period 2008-2012, emissions of six greenhouse gases (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6) by at least 5% compared to 1990 levels.

Greece has pledged that its emissions will not increase more than 25% over 1990 levels by 2008-2012. Overall increase in greenhouse gas emissions compared to the base year would be 34.7% in 2010 and 49.4% in 2020.

3.14.2 Legislative framework at European Level

Today, within an increasingly interdependent and changing world, Europe is facing new challenges such as globalization, climate change, energy supply, new security threats. The member countries are no longer able to cope alone these problems. Only by joining forces at European level could help .That is the purpose of the **treaty signed in Lisbon on 13 December 2007**.

The Heads of State and Government, taking into account the political, economic and social developments reached an agreement on new rules that should govern future action of the Union. The Lisbon Treaty is the result of negotiations conducted between the member states and entered into force on 1 December 2009.

We have the **Treaties of Rome in 1957** ,which established the European Economic Community (EEC) and the European Atomic Energy Community (EURATOM).It was signed by representatives of Belgium, West Germany, France, Italy, Luxembourg and the Netherlands on 25 March 1957 and the date of signature is considered the official birthday of the European Union.

The status of the RES was determined by the Treaty establishing the EEC for 50 years, amending the **Treaty of Maastricht in 1993**, which assigned task for the EU to adopt measures for the energy sector.

3.14.3 Legislative framework at national level

3.14.3.1 Legal framework for renewable energy and hydropower stations

The implementation of the 2000 European Water Framework Directive (2000/60/EC) has been an important driving force behind the development and evaluation of integrated hydro-economic models in a number of European Member States (Brouwer et al., 2007).

1. ***Law 3851/2010:*** "Accelerating the development of Renewable Energy Sources to deal with climate change and other regulations addressing issues under the authority of the Ministry of Environment, Energy and Climate Change"
2. ***Law 3734/2009:*** "Promotion of Cogeneration two or more useful forms of energy"
3. ***Law 3468/2006:*** "Production of Electric Energy from RES" (Official Gazette A' 129/27.06.2006)
4. ***Law 3175/2003*** :"Development of Geothermal Power" (NG A'/ 207/ 29-8-2003)
5. ***Law 3010/2002*** :"Harmonization of L. 1650/86 with the Directives 97/11/EC και 96/61/EC" (NG A'/91/25-04-2002)
6. ***Law 2941/2001:"***Simplification of the procedures for the establishment of companies, licensing of plants using renewable energy sources, regulation of matters pertinent to Hellenic Shipbuilding S.A. and other provisions" (Government Gazette Part A, No.201)
7. ***Law 2773/1999 :*** «Liberalization of the electricity market adjustment of energy policy» (NG /A' 286/22-12-99)
8. ***Law 2647/1998*** : «Devolution of competences to Regions and Local Governments» (NG A' 237/22-10-98)
9. ***Law 2503/1997:*** «Organization and Recruitment of Local Governments»
10. ***Law 2244/1994*** :«Production of Electric Energy from RES» (NG A'/168/07-10-94)
11. ***Law 1739/1987*** : "Management of Water Resources" (NG A'/201/20-11-1987)
12. ***Law 1650/1986:*** «For the Protection of the Environment» (NG A'/160/15-16.10.1986)
13. ***Law 1475/1984*** :"Development of Geothermic Power" (NG A'/131/11-09-1984)

Law 1739/1987: **"Management of water resources and other provisions"**

It has been enacted in order to establish a new system for water management and introduces the obligation of acquiring a special licence for every use of the water.

Undoubtedly, water resources are considered to be indispensable for the preservation and maintenance of ecological balance. During the last decades there is an increasing demand for an adequate quantity of water, imposed by the constant needs of agriculture, industry, tourist development and the expansion of cities. The increasing demand for water, in combination with the simultaneous increase of the pollution sources, causes serious problems to the development of several areas. It has been realized that these problems could be confronted with a comprehensive national water policy, based on the rational management of the "water resource - use of water resource" system.

Law 1739/1987 aimed to establish the procedures and the administrative bodies that would regulate water resources management at a national and regional level.

Law L2773/1999 : "Liberalization of the electricity market"

It maintained the favourable pricing regime for RES-E by also placing emphasis on priority access to the grids. At the same time, it introduced a fee of 2% on the renewable energy proceeds for the benefit of the relevant local government organizations. Furthermore, the renewable energy sale rates were deemed as "cap prices" and the Minister of Development was given the authority to ask for a discount. Tariffs were guaranteed for 12 years with the possibility of extension up to 20 years.

Law L3468/2006: "Generation of electricity from renewable energy sources and through high-efficiency co-generation of electricity and heat and miscellaneous provisions"

It set in detail the pricing of electricity produced from RES, introducing technology specific tariffs, higher tariffs for small size PV units and off shore wind and higher tariffs for the energy produced by RES units operating in the non-interconnected islands. Remuneration of the electricity production was set in article 13 of L3468/2006 as follows:

Table 3.10: Remuneration of the electricity production was set in article 13 of L3468/2006

Electricity production from:	**(€/MWh)**	
	Mainland	**Non-interconnected islands**
Wind energy	73	84.6
Off-shore wind energy	90	
Small Hydro electric plants < (15) MWe	73	84.6
Photovoltaics < (100) kWpeak, Photovoltaics > (100) kWpeak	450 400	500 450
Solar energy from units other than photovoltaic < (5) MWe Solar energy from units other than photovoltaic > (5) MWe	250 230	270 250
Geothermal energy, biomass, landfill gases sewage treatment plants and biogases	73	84.6
Other RES	73	84.6
High efficiency cogeneration of heat and electricity	73	84.6

Source: L3468/2006:Production of Electricity from Renewable Energy Sources and Cogeneration and high efficiency heat and other inter- classes

With Ministerial Decrees issued after an opinion by RAE the feed-in tariffs set by L3468/2006 were re-adjusted for the years 2007 and 2008, reaching in 2009 the following values:

Table 3.11: Remuneration of the electricity production was set in 2009

Feed in tariffs valid for 2009		
Electricity production from:	**(€/MWh)**	
	Mainland	**Non-interconnected islands**
Wind energy	87.84	99.44
Off-shore wind energy	104.84	
Small Hydro electric plants < (15) MWe	87.84	99.44
Photovoltaics < (100) kWpeak, Photovoltaics > (100) kWpeak	454.73 404.20	505.25 454.73
Solar energy from units other than photovoltaic < (5) MWe Solar energy from units other than photovoltaic > (5) MWe	264.84 244.84	284.84 264.84
Geothermal energy, biomass, landfill gases sewage treatment plants and biogases	87.84	99.44
Other RES	87.84	99.44
High efficiency cogeneration of heat and electricity	87.84	99.44

Source: Law 3734/2009

Law 3734/2009: "Promotion of Cogeneration two or more useful forms of energy"

With L3734/2009 the tariff of the electricity produced from photovoltaic plants is modified, taking into account the significant reduction of the relevant investment cost during the period 2006-2009.

L3851/2010 : "Accelerating the development of Renewable Energy Sources to deal with climate change and other regulations in topics under the authority of MEECC".

The new law complements L3661/2008, by setting new requirements that stipulate the coverage of 60% of the need of new buildings for hot water by solar thermal systems after 1 January 2011.

Additionally, all new building construction or major renovation requires henceforth a full energy analysis study that includes energy conservation and cost/benefit analysis of the utilization of RES cogeneration, district heating, and heat pump systems.

Furthermore, L3851/2010 stipulates that by 31.12.2019, all new buildings must cover the total of their primary energy consumption with RES, CHP, district heating on a large area scale/block scale as well as heat pumps. This requirement is extended to all new public buildings by 31.12.2014 at the latest.

The feed-in tariffs set by L3851/2010 currently applicable as of 4 June 2010 are given in the table below:

Table 3.12:The feed-in tariffs set by L3851/2010

Feed in tariffs set by L3851/2010, valid as from June 2010		
Electricity production from:	(€/MWh)	
	Mainland	Non-interconnected islands
(a) Wind energy >50kW	87.85	99.45
(b) Wind energy <50kW	250	
(c) Small Hydro electric plants < (15) MWe	87.85	
(d) PVs in households or small enterprises < (10) kWp	550	
(e) Solar thermal energy	264.85	
(f) Solar thermal with storage system (at least 2h at nominal load)	284.85	
(g) Geothermal energy of low temperature	150	
(h) Geothermal energy of high temperature	99.45	
(i) Biomass ≤1MW (excluding biodegradable sewages)	200	
(ia) Biomass >1 and ≤5MW (excluding biodegradable sewages)	175	
(ib) Biomass >5MW (excluding biodegradable sewages)	150	
(ic) Landfill gases sewage treatment plants and biogases (including biodegradable sewages) ≤2 MW	120	
(id) Landfill gases sewage treatment plants and biogases (including biodegradable sewages) >2 MW	99.45	
(ie) Gas from biomass ≤3MW	220	
(if) Gas from biomass >3MW	200	
(j) Other RES	87.85	99.45

Source: L3851/2010

PPAs are valid for 20 years for all RES units with the exception of solar thermal units for which a 25-year duration is foreseen. The PPA duration may be extended after a bilateral agreement provided that the relevant generation license is still valid. The tariffs from case (a) to case (h) and case (j) of the table are increased by 20% if no state subsidy is made available to the producer. For biomass/biogas feed in tariffs, the corresponding increase is set at 15%.

Further provisions of Law L3851/2010 are:

(a) An increase set by Ministerial Decree of the feed in tariff with which wind energy producers will be remunerated in case the operating units are installed in areas of lower wind potential.

(b) In case the system operator decides to curtail RES production, the producers are compensated for up to 30% of the curtailment. The percentage increases each year and may reach up to the maximum of 2200 equivalent hours of operation without curtailment.

(c) For electricity produced from wind parks operating in the islands and connected to the mainland System by the developer, the tariff set for wind parks in non-interconnected islands applies throughout the entire duration of the PPA, increased by a percentage ranging from 10 to 25% depending proportionally on the distance of the connection line and reversely on the total installed capacity of the unit.

3.15 License to produce electricity from RES or Combined Electricity and Heat with High Performance

The license for the production of electricity from RES and CHP are granted by a decision of the Regulatory Authority for Energy based on the following criteria:

a) The national security.

b) The protection of public health and safety.

c) The overall safety of the facilities and equipment of the System and Network.

d) The energy efficiency of the project for which the request is made, such as profitability arises, for RES projects, from measurements of the potential of RES and CHP units from the energy balance. Especially for wind potential, the submitted measurements must have performed by certified operators, according to the standard DIN-EN ISO/IEC17025/2000, as is the case every time.

e) The maturity of the implementation process of the project, according to studies carried out, opinions competent services and other relevant information.

f) Ensuring the possibility of collateral or the right to use the location of the project.

g) The ability of the applicant or its shareholders to implement the project based on the scientific and technical competence and the ability to ensure adequate financing of equity or bank financing the project or venture capital or a combination of them.

h) Ensuring utilities and customer protection.

i) The feasibility of the project in compliance with the Special Framework for Spatial Planning and Sustainable Development for RES particular with exclusion areas for siting facilities RES, since these areas are delineated in a specific and concrete, as well as provisions for the control of carrying capacity in the areas permitted RES to ensure the principle of environmental protection.

i) The compatibility of the project with the National Action Plan for achieving the objectives set out in paragraph 3 of Article 1 2010.

3.16 Procedure for licencing

For the construction and operation of a power plant by RES, there is a need for relevant permits and signing contracts . Generally, the steps that need to be made are:

1. Edition of Electricity Generation License (RAE).
2. Simultaneously (parallel processes) applications:
   - Formulation of the Connection Offer plant to system or network (responsible Manager - PPC or TSO).
   - Approval of Environmental Terms (HFF) or HFF Exemption (Region).
   - Unauthorized forest or wooded area if needed, or generally necessary permits to obtain the right to use the location of the project (Region).
3. Simultaneously (parallel processes) steps:
   - Installation License Version (with integrated Single License and Water Works Execution when it comes to small hydroelectric plants) (Region).
   - Building permits (where required performance construction) or other permits and approvals may be required and may be issued without even the Establishment License (Urban or competent authority as appropriate).
   - Contract Signing Connection System or Network
   - Power Purchase Agreement Signed (TSO)
4. Trial period and licensing (Region).

As shown in the relevant "Panel Permits and Approvals Project RES", the process is different depending on the installed capacity of the power plant, the technology used and the location.

The license to produce electricity from RES and CHP granted for a period up to twenty five (25) years and may be renewed up to equal time.

3.17 Hydro plant that we study

As shown in the table, the hydroelectric station is connected to the grid so this investment belongs to the third pricing group and the market price is 87.85 €/MWh. So the income unit under review for the first year from the sale of energy in PPC will amount to the sum of 1.317.750€.(15 GWh/έτος *87,85€/MWh).

One of the most important issues in planning the ‘‘reservoir” type of hydro-power plants (HPP) is to determine the installation capacity and estimate its annual energy value.

Energy calculation

The calculation of energy is based on the status table of the output and overflow of the accessible water monthly and even daily, as well as the net level of water recorded in different years .The net height of the reservoir is a function of the input of water into reservoir and also the level of the water in the reservoir .Therefore, the height is not fixed in different months. The useful net height can be extracted from the subtraction of the level of water in the reservoir and the level of axis of turbine .Basically, the relationship between power and water flow and the head water is as below:

$$P = 9.81 \cdot \eta \cdot Q \cdot H = A \cdot Q.H \quad \text{(kW)}$$

which

$A = (\rho \cdot g \cdot \eta)/1000$ is a coefficient
$\eta =$ the efficiency of the turbine/generator
$Q =$ design flow through the turbine (m^3/s)
$H =$ net (effective) head (m)
$\rho =$ water density (kg/m^3)
$g = 9.81$ (m/s^2)
$e_i = P_i \cdot t_i$ (kW h) as generated energy
$e_{pi} = P_i \cdot (365 \times t_p)$ (kW h) peak generated energy
e_m (kW h) monthly generated energy
P_i (kW) rated power
t_i (h) operation hours
t_p (h) daily peak hours
$e_a = \sum_{n=1}^{12} e_{mn}$ (kW h) annually generated energy

Figure 3.18: The calculation of energy

Source : Hosseini et al,2008, Pallav,2008,Aslan et al

The amount of energy generated during different daily hours and/or different seasons of the year are the most important issues worthy of study in the reservoir type of HPPs studies.

The flow-of-river of a hydro may vary a lot during a year so this calculation is based on the minimum flow. The design flow is of great importance of the efficiency of the power station (O. Paish,2002), so designing a power station for a large flow which is only available during some parts of the year will have a higher installation cost and will have a very bad efficiency when the there is low flow-of-river . (Math H.J. Bollenb,2005)

The net drop height is 14 meters and the downstream supply output continuously at 0.3 m3 / s. The total annual energy is 15 GWh / year.

Table 3.13: By month electricity production of the hydro plant

By month electricity production

						KWh
October	8,66	9,1	14	24	31	820843,3
November	8,66	9,4	14	24	30	820552,3
December	8,66	11,8	14	24	31	1064390
January	8,66	12,3	14	24	31	1109491
February	8,66	16,1	14	24	28	1311720
March	8,66	16,5	14	24	31	1488342
April	8,93	21,2	14	24	30	1908305
May	8,93	19,4	14	24	31	1804489
June	8,66	15	14	24	30	1309392
July	8,66	8	14	24	31	721620,5
August	8,66	7,8	14	24	31	703580
September	8,66	8,3	14	24	30	724530,2
Sum						**13787256**

Based on these monthly benefits we choose 2 units with an $I_1 = I_2 = 1,5$ MW respectively.

These units will operate as follows:

Unit 1: October-November-December - January - July - August - September

Total days: 215

Unit 1 + Unit 2: February - March - April - May - June

Total days: 150

So we average hourly net power (MW) available to the system: 1,5 MW

Maximum net power available from the production facility for the system: 3 MW

We believe that energy production of 15 MW every year remains constant while the income of the company is revalued by 3.5% revalued as inflation as shown in the following table.

Table 3.14: Annual revenues of hydroelectric by applying price increases on Budgets

Annual revenues hydroelectric by applying price increases on Budgets

	Energy produced (GWh)	Annual income (€)
Year 1	15	1.317.750
Year 2	15	1363871,25
Year 3	15	1411606,744
Year 4	15	1461012,98
Year 5	15	1512148,434
Year 6	15	1565073,629
Year 7	15	1619851,206
Year 8	15	1676545,999
Year 9	15	1735225,108
Year 10	15	1795957,987
Year 11	15	1858816,517
Year 12	15	1923875,095
Year 13	15	1991210,723
Year 14	15	2060903,099
Year 15	15	2133034,707
Year 16	15	2207690,922
Year 17	15	2284960,104
Year 18	15	2364933,708
Year 19	15	2447706,387
Year 20	15	2533376,111

3.18 SWOT analysis

Globally, investments in the sector of Renewable Energy totaled $ 211.000 million to 2010 from $ 160.000 millionto 2009 (31.9% increase). These investments include:

A) Assets on finance

B) Venture capital

C) Private capital investment

D) Public markets shares and

E) Investment in research and development (public and private)

The corresponding amount of total investment in 2004 was $ 22.000 million

The funding of new projects for small hydroelectric power stations decreased 43% to approximately $2.000 million in 2010.The investments were affected by the global economic downturn, certain institutional constraints that apply in Europe ,as well as concerns about the wide variation of rainfall will affect some projects.

3.17.1 SWOT Analysis

STRENGTHS

A) The highly exploitable energy potential of the country (windy, sunny, etc.)

B) The nature of RES

C) The country's commitments and the EU for green growth

D) The fixed price sale for at least 20 years from the summary of the contract

E) The introduction of new technologies and the continuous improvement of expertise.

F) The low operating costs of RES.

G) The powerful business models in the industry.

OPPORTUNITIES

A) The large growth margins of the examined sector.

B) The formulation and enactment actions with immediate horizon aimed at further development of RES.

C) The proper implementation of the programs 'Sun'

D) The further development of profitable and contribution to the national economy RES

F) The institutionalization of smart electricity grids.

G) The increasing interest investments acid sequence.

WEAKNESSES

A) The low level of implementation still holding RES investment projects compared to existing features.

B) The delay in the implementation of infrastructure .

C) The saturation of networks in areas with high energy potential.

D) The high capital needed for RES projects which prevents investments in downturns like the current one.

THREATS

A) The effect of the economic downturn resulting in a lack of financing tools for development works.

B) The exclusion from the scheme of the development law of production and / or R from P / V systems.

C) The decline in selling prices H / E RES.

D) Delays in some cases in the payments and / or E.

E) The reactions of some local communities and lack of universal social acceptance of RES. (Local interests, lack of information etc.)

Chapter 4 - Raw materials and other supplies

4.1 Characteristics of raw materials and other supplies

4.1.1 Raw materials

The main raw material of a hydroelectric power plant is water. In a hydroelectric power station it takes place the conversion of potential energy into kinetic. The amount of electric power that a hydro station can produce depends on the amount of water discharging through each unit. This depends on the height at which the water falls and the losses during this fall. (Klein and S.H., September 1991)

In the specific hydroelectric plant the water comes from a river which is in the region of Karpenisi.

4.1.2 Supplies of a hydropower plant

In order to be successful in its functioning and strategic objectives ,a plant needs and some other supplies such as:

1. Electricity and diesel
2. Tools for theTechnical department
3. Maintenance materials
4. Work wear

4.2 Characteristics of raw materials and supplies

While determining the necessary inputs someone should take into account the possible capacity of the unit and the desired level of production which depends on various factors of engineering which are often dependent on the supplier's ability of raw materials and other supplies which are used for the manufacturing of the final product.

For the smooth every day operation of the hydro plant it is necessary to make a standard budget for supplies and quantify the needs of the hydro .

Table 4.1: Required inputs per year

1. Ancillary materials and services of general interest
Electricity and diesel
2. Technical department tools
Tools
3. Maintenance materials
Paintings
Grease-Oils
Other materials
4. Work wear
Workwear for painting
Workwear for general working
Helmets
Footwear

4.3 Availability of raw materials and supplier selection

4.3.1 Availability of materials

It is important to ensure the availability of the supplies of theelectricity unit to cover the capacity of the unit as well as the health and safety of workers.

4.3.2 Minimizing cost

The company aims to minimize production costs per unit of electricity by concluding long-term agreements with suppliers.

4.3.3 Selection and evaluation of suppliers

In supply chain, supplier has an important role. Supplier selection is sometimes highly complex, since it incorporates a great variety of uncontrollable and unpredictable factors that affect the decisions. Moreover, supplier assessments or ratings should be done routinely to ensure that incoming materials meet relevant quality standards (Bevilacqua, 2006).

The most common supplier’s evaluation criteria are:

a. To keep up with critical situations
b. Meeting the demand
c. Meeting the cost requirements
d. Process capability and quality
e. Personnel capability
f. To match the lead times
g. To be solution-oriented
h. Accessibility
i. To keep up with technological developments
j. Communicating
k. The general efficiency (Bilisik et al,2012)
This way the unit will ensure the continuity of production.

4.3.4 Cost of raw materials and other supplies

The cost of raw materials and other supplies is a key component to the success of the investment and should pay special reference based on the cost per unit of each input and the required quantities.

The operating costs for the hydro plant´s first year are shown in the table below,

Table 4.2: Cost estimation of raw materials and other supplies

Necessary inputs per year	
Inputs	Annual cost (€)
Electricity and diesel	71.261
Tools	23.754
Workwear	1.889
Maintenance materials	3.385
Total	***100.289* €**

The cost of raw materials and other supplies will be adjusted every year by 3,5 % as the rate of inflation as shown in the table below.

Table 4.3: Annual cost of raw materials and other supplies with increments of inflation rate

Year	Annual cost (€)
Year 1	100.289
Year 2	103.799
Year 3	107.432
Year 4	111.192
Year 5	115.084
Year 6	119.112
Year 7	123.281
Year 8	127.596
Year 9	132.061
Year 10	136.684
Year 11	141.468
Year 12	146.419
Year 13	151.544
Year 14	156.848
Year 15	162.337
Year 16	168.019
Year 17	173.900
Year 18	179.986
Year 19	186.286
Year 20	192.806

Chapter 5 - Engineering and technology

5.1 Program and production capacity of the plant

The selection of the proper machinery will be completed by the manufacturing program of the project study. The production of the unit is determined by the respective local and national needs for energy market.

The station has a capacity of 3 MW and the annual energy produced is expected to approach 15GWh.Therefore the facility will produce electricity for 5000 h (15GWh/3 MW) namely average 16,7 h/day and 300 days per year. The lifespan of the project is 20 years and it increases with the renewal of electromechanical equipment. Consequently the selection is a critical factor for the effectiveness and to prolong the life of the project.

5.2 Technology selection criteria

The choice of the equipment is done with the following criteria:

1. Meet the needs of the program and production
2. To operate at peak efficiency and in future some improvements could be done.
3. To create an intimate, secure social environment
4. Be friendly to the user and to create a safe environment for their employees.
5. Must not affect the quality of water.
6. Lead to the social development of the region without altering the natural beauty of the area.
7. To create opportunities to the locals during the construction and the operation of the Project. (Galousis ,2009)

5.3 Supplier selection

In recent years, more and more pay particular attention to the identification and selection among alternative supply sources (Raydel & Lee, 1994)

Supplier evaluation attributes fall into five main categories:

1. **Competitive pricing** (‘Lower prices’ is the most frequently cited reason for pursuing a purchasing strategy).(Katsikeasa,2004)
2. **Reliability** (Piercy et al. 1997 showed that “ The supplier’s honesty and regular communication with the buying firm influence, the purchasing decision process pertaining to choice of supply source”)
3. **Technological capability** (Modern purchasing processes include auditing the ability to contribute to future product development (Monczka, Callahan & Nichols,1995).
4. **Service** (performance, quality, management, and service-related capabilities of the supplier (Wilson, 1994)
5. Swift 1995 concluded that “**Delivery** is one of the most important aspects of a multiple-sourcing buying situation”

5.4 Required technology

5.4.1 Description of the main components of a hydroelectric plant

The figure below (Figure 5.1) represents a typical micro or pico hydrodynamic system (http://www.hydrogeneration.co.uk).The parts that we can see are:

1. A barrier that stops the flow of the river leaving a small passage for the fish
2. A channel constructed so as to guide the water supply enters the installation.
3. Input gates regulating how much of the water bypass and bring it to the system

4. A short water pipe leading the water to the turbine and the generator.
5. A water turbine connected to a generator
6. A channel escape through which the water returns to the river.

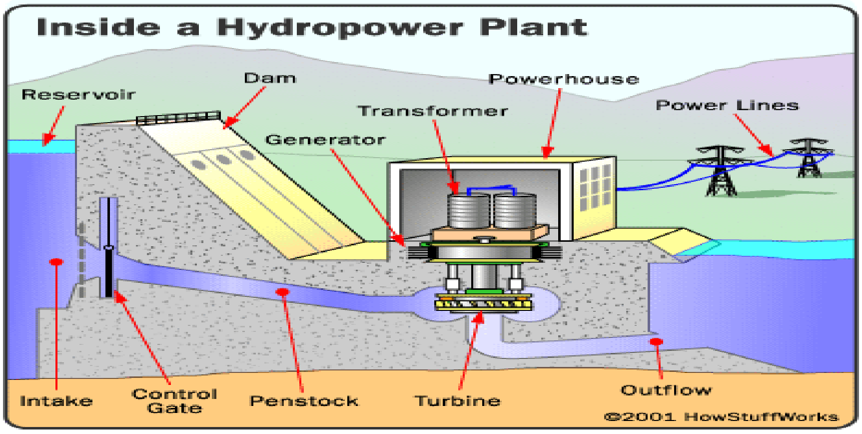


Figure 5.1: Micro-hydrodynamic system

Source:www.google.com

The abstraction is designed so that a portion of the flow (ecological flow) attributes directly to natural watercourses in order to maintain sufficient conditions survival for riparian ecosystem. Where it is necessary a technician facilitator is manufactured to enhance the movement of the fish along the bed (auction, fish ladder). On lateral abstracting we integrate gates to the ramp for the evacuation of debris, so that in each case not to prevent sediment along the bed. Generally the existing bed ranges between 0-5 m. (Mega)

Once detached the water from the bed it is channeled by free flow tank precipitation or desilter. The settling tank is sized to ensure the retention of the minimum dimension grain sediments, determined by the specifications of the vortex.

After the desilter there is the forebay, which is designed to ensure appropriate hydraulic conditions in the pressurized inlet duct. The basic criterion for the design of the tank is that it should not charge input air in duct, which can create cavitation problems.

The main technical task of the delivery system is the conduit through which is transferred the provision to the turbine .The material and dimensions of the conduit are selected by techno-economic criteria, such as seeking the optimum economic solution that meets specific technical design criteria .The pipeline route depends on the position of the tank, the existing topography and geological conditions of the area .The length can be from a few hundred meters to a few kilometers .A hydroelectric plant consists of civil engineering and electromechanical equipment.

The typical materials that are used are steel, synthetic materials (PVC, GRP), reinforced or unreinforced concrete (tunnels) and more rarely wood. The selection of suitable material relates to the installation conditions and the available resources and manufacturing capabilities. Basic criteria for selection of the diameter is to reduce hydraulic losses and costs, and the speed at specific levels (1 ~ 5 m / s). In order to reduce transport costs we often select two or three distinct diameter tubes and the smaller ones are placed in the biggest ones (nesting).

The installation of the pipeline may be underground or surface. The duct is usually placed in sandpit for environmental reasons .Moreover the necessary cabling for the remote control gates of the hydo plant are mounted in the duct.

5.5 Technical description of civil engineering

The main parts of the work of a civil engineering are to:

- ✓ Create a river diversion project to build upstream and downstream barriers against overflowing .
- ✓ Construct the body of the dam that will have fish passages stepped to the seamless movement in both directions.
- ✓ Build a Power Plant Project for housing units and control panels.

- ✓ Build a Project substation configuration with the appropriate space next to the installation of the power plant to install the M / S lift and connection to the local grid.
- ✓ Construction of an access road to the dam and the power station by passing the entrance to the canyon road Fidakia -Ambelion or-Bridge Episkopi-Agalianos.

Each unit will be connected to the M / S lift .In the area of M / S there will be installed some measuring instruments of the energy and power in highly designed space. The line for the connection the network (20 KV) is in the air and has a length of approximately 3 Km.The cost of connecting to the grid is estimated at **107.115 €**

The engineering construction generally constitute interference in the natural and human environment .Specifically for Small Hydro Projects such as this one the impact on the environment is almost nonexistent by taking remedial measures:

- There is only using water and no consumption
- The bed of the lake formed upstream of the hydrant project is so small in size that creates the impression of a more physical exploration of the river rather than a reservoir.
- Provide continuous water to maintain the ecosystem in accordance with applicable law.
- It will allow continuous movement of fish with proper construction.
- The building of the power plant is small in volume due to the size of the turbine and it will meet the aesthetic requirements of the area taking into consideration the architectural tradition of the region.
- Special consideration will be given to the special construction debris to be retain upstream project diversion dam.

The dam project on the river Trikerioti is placed next to the exit of the existing canyon located about 1.5 km from the bridge of the Episkopi of the Highway Karpenisi-Agrinio. The station is placed in the right shoulder and adjacent to the foot of the barrier. Almost immediately downstream of the location of the project there is the artificial lake of HEP .

Rafting athletes will take special care with the construction on the dam because the project area is in the termination of the descent of the river body.There will be constructed a special diode for boats crossingthe river in accordance with the international standards ..

The current project will be designed and constructed as follows:

A. Abstraction

The catchment area is 590 km^2 with flood frequency 1/50 and dam height 15 m. The water intake is fitted with manually operated slide gate valve cleaning to remove sediment. The sand collector is constructed of reinforced concrete with an inclined floor, while upstream is sluice for controlling the supply to the passing sand collector. The spillway has a sand collector box and plate for protection. In sand collector there has been installed an electronic water level meters for automatic operation unit which gives signal to the control system of hydropower plant.

B. Duct

The adduct of water will be carried out with two conductors which consist of steel pipes, with a total length of 150 m and a diameter of 3,60 m. surrounded by concrete 1 m. The conduit is under earth in depth of 1,2 m and width of 1,0 m, which will opened in the position of the current channel. Also, the surface of the soil is strongly vertical and rocky. In places where the route changes sharply or tilting tube, there will be enhacement with concrete bodies anchoring. The chute tube will consist of straight pieces helically welded steel pipe sheet thickness such as to ensure a minimum dynamic pressure resistance of 4-16 bar. The steel pipe is fitted with expansion joints for receiving temperature expansions in aboveground parts where needed. All steel conductors will be carrying internal corrosion protection with coating thickness of 150-200 mm and externally with two layers of butyl and an intermediate layer of polyethylene film . There is also a planned backfilling and planting intention.

C. Building works

The hydroelectric station is a two storey building constructed mainly of concrete.Its total size is about 160 m^2. The roof consists of a triangular inclined plate which is coated with tiles with traditional appearance. The turbine is mounted in a special configuration of the floor of the building, while the rest of the equipment will be mounted on the floor. On the floor of the building there will be based units with concrete anchors . The entrance of the power station will be an industrial type steal door with 3 m wide ,so we can pass the equipment which will be installed in the building .Also the floor covering will be industrial type.

The hydroelectric plant has a small space for security and maintenance of the station. The permanent staff of hydro plant will consist from one to two people. The foundation of the building is calculated based on the geomorphologic features of the area and the laying used for the reference plane was gros-beton.

To address the noise the perimeter walls of the building were constructed of reinforced concrete. It is understood that in the surrounding area we will put trees and the factory building will resemble to a cottage in a lush garden.

Tables MV will be installed in a separate lockable room of the hydroelectric station. The transformer will be placed outdoors of the building of the hydroelectric power plant and the area will be fenced off for safety reasons. Beneath the site's transformer gravel there will be an oil collector in case of accidental leakage. MV tables which comply with Regulation IEC 193 will be connected with the side transformer lifting, as well as the transformer auxiliary power to the grid of PPC. MV tables will be designed for maximum output short circuit and will be also protected by lightning rods located in the output field to the grid.
The substation will be built at a distance from the main station with dimensions 6X6.

<u>The technical characteristics of the project</u>

Type: In the course of the river

Total installed power = 3 MW

Annual energy output = 15 GWh

Year project life = 50 years

The total cost of a small hydroelectric split into:

1. Cost engineering
2. Cost electromechanical equipment (installed), and
3. Cost of network connectivity.

Further analysis of these 3 components of the total cost of the station has a small hydroelectric station as follows:

1. The cost of **civil works (KG)** was calculated as the sum of the cost of the following main components:

- cost of abstraction,
- cost of the Desilter
- cost delivery channel,
- cost duct,
- cost tank charging
- cost of access roads,
- cost of the generating station

2. The cost of **electrical equipment (KM)** is derived as the sum of the cost the following main components:

- cost of turbines,
- Cost governor,
- cost of power transformer,
- cost generator
- cost of electrical panels

3. The cost of **connecting to the network (Ks)** is a known value, which is determined by the administrator of the transmission of electricity.

The total investment cost K as follows: **K = KG + KM + Ks**

Generally, the construction of the buildings on the site of the station require building permition or certificate issued by the city planning .For the hydraulic structures the designer, the contractor and the project promoter are entirely responsible. (http://www.desmie.gr/ape-sithya/adeiodotiki-diadikasia-kodikopoiisi-nomothesias-ape/periechomena/diadikasia-adeiodotisis/oikodomikes-adeies-ergon-ape/)

5.6 Costing of civil engineering

Table 5.1: Cost estimation for civil enginnering projects

	Cost Estimation
A. Civil engineering projects	
1.Study	40000
2.Before dams	
Excavations	21600
3.Pipeline drain	45000
4.Dam-Water inlet- Desilter -Fish entrance	
Excavations	443453
Concrete	105525
5.Station building production	
Excavations	10560
Concrete	80595
Mansory	34560
Architectural	499510
6.Sub station	
Excavations	4032
Concrete	36652
Architectural	74367
formation of the external environment	20000
Total of civil engineering projects	1415854

5.7 Electromechanical equipment

The electromechanical equipment consists of turbines, their drives, the generators, transformers, electric tables and ancillary equipment such as forklifts machinery (cranes), the system pressure oil and air, the automation etc. Each generator is directly connected to the turbine, except for very small units which interfere with gear transmission. The purpose of the transformers is the elevation of the voltage producing Generators in high voltage grid so that the transfer of energy is done with minimum losses. The number of units, assemblies turbine-electric generator-transformer etc., depends on the program of production of the project, taking into account the variability of benefit need peaks coverage network etc. and naturally are determined by economical criteria. For safety reasons, the number of units of a large hydroelectric plant is typically greater or equal to two. In this way it is possible to maintain a more flexible production schedule.

5.7.1 Overview - Types of hydroturbines

The turbines (http://www.microhydropower.net) convert the energy of the water which falls into force.Rotary axis turbines can be divided into turbines of action and turbines of reaction, depending on the procedure used to convert hydraulic head and water supply into mechanical power.

The minimum and maximum flow rates, and the range of operation determine the level of energy that can be produced in one location. The efficiency of energy conversion of units turbine-generator is normally 80-85% and the turbines are classified either according to the direction of water flow in the flaps: axial, radial, or combined flow, either: reaction incidence, combination reaction-incidence.

There are many different types of turbine configurations available for low-head small hydro developments. Both axial flow (propeller) and radial flow (Francis) turbines can be used in about 10 different configurations, resulting in considerable difficulty in arriving at the most economical and appropriate unit. (Gordon J.L.)

The turbines of action (US Department of Energy, 1983) are usually used in cases where we have a large amount of power and low price for water supply. The most basic types of action are the turbines: Pelton, Turgo and Cross-Flow.

- Pelton wheel

The Pelton wheel was named from its creators and is the most popular turbine action. The inlet section consists of one or more nozzle, whose purpose is to convert the potential energy to kinetic, by forming one or more beams of circular cross section. In optimal operating conditions, using a turbine Pelton, can be achieved efficiency up to 90%.

- Cross-Flow Turbines

The turbine cross-flow (or Banki) created to manage larger benefits water and lower hydraulic height, compared to the hydraulic turbine Pelton. The efficiency of the turbine cross-flow, mainly due to the more complex flow path, ranging in values around 65%

- Turgo turbine

A Turgo turbine is an impulse turbine effect, which may manage larger values for water, in relation to the Pelton wheel. An advantage of the impulse turbine Turgo is that, for the same hydraulic force and for the same diameter rotor speed is about twice, always in relation to the turbine Pelton. Here, the efficiency can reach values as 92%.

In turbines of incidence fluid falls on the turbine and forces it to rotate, while the reaction turbines are integrated into the flow and exploit the fluid pressure drop between the inlet and outlet of the turbine. The reaction turbines have the advantage that their functioning can be reversed, and act as pumps to transport water higher level, ensures thereby saving energy.

The turbines of reaction (US Department of Energy, 1983) are usually used in cases of lesser power and higher prices for water supply. One advantage of a reaction turbine is that it achieves a good efficiency. The most basic types of turbines of reaction are turbines Francis, Kaplan, the axial flow turbines and bulb turbines.

- Francis turbine

This type of design was first developed in the late 19th century, enjoyed wide acceptance and was used in a large range of hydraulic head and flow characteristics. The flow is usually controlled from about 12 to 24 gates dam, which regulate the rate of flow, but also changing the angle of the flow. The Francis turbines can achieve very good efficiency even for benefits equal to 50% of the design.

- Kaplan

Sometimes in large-scale installations we use turbine-type Kaplan. Varying the slope of all the blades together, with appropriate adjustment of the dam gate, enables managing very large range of water supply, while achieving very good efficiency. The specific speed of the turbine Kaplan takes very large values, which allows direct connection to the generator, but only for higher altitudes and lower hydraulic flow rates of water. Although Kaplan type turbines provide 90% or better price in efficiency benefits by 35% or more of the maximum flow, are mainly used only in larger facilities because of their high cost. (Katerinopoulos Philip.,2007)

- Bulbous turbine

The bulb turbines were named after the shape of the sealing wrappers. They have now replaced the Kaplan turbines for small values the hydraulic head, for which the speed of the generator must be increased

Table 5.2: Classification of turbines used for pico-hydro based on hydraulic head and type

Turbine type	Low (<10 m)	Medium (10–50 m)	High (>50 m)
Impulse	Crossflow	Crossflow Turgo Pelton	Turgo Pelton
Reaction	Francis Propeller Kaplan	Francis	

Source: (Cobb, Sharp, 2013)

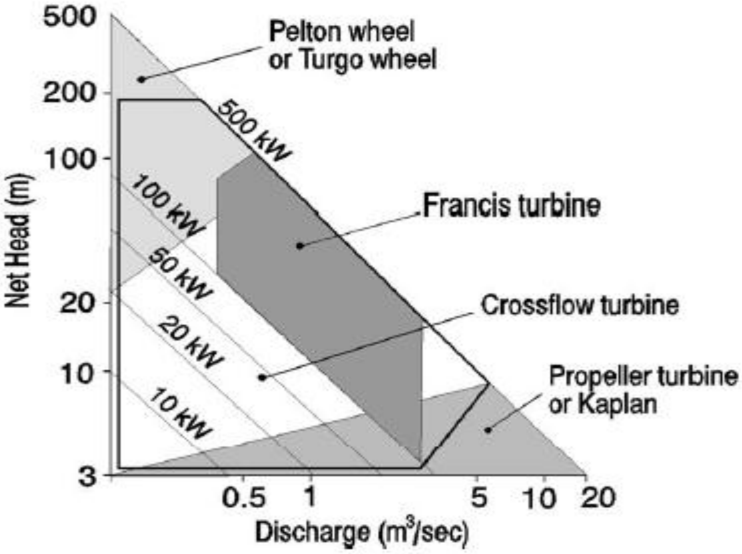


Figure 5.2: Head-flow ranges of small hydro turbines

Source:Paish,2002

In the hydro plant that we are studying, based on the duration curve benefits and better exploitation of incoming input we will determine during the preliminary design stage and the type and number of units and will seek to optimize the selection of electrical / mechanical equipment.

The operation from energy from hydro will start with maximum flow in turbines equal to 25 M^3/sec. Each turbine unit is supplied with control unit, which consists of the hydraulic and the electrical part. Each generator of the module is synchronous, three phase, air cooled, and linked to appropriate link with the axis of the corresponding turbine. The axis of each generator is supplied with lubricating bearings.

Operating voltage is set at 6 KV and frequency 50 HZ. In the Control Panel will be installed automation system and power regulation unit, the protections of the generator and related equipment. To protection of the units will be installed in the appropriate relays according to the requirements of the PPC. For the operation of the units there will be installed electronic water level meters. The operation of the plant will be fully automated and controlled by the signal will result in an automation system from the upstream water level meters. The transformation will be lifting air-cooled, three-phase, oil and installed in a specially designated area outside the plant. The tables of the transformer will be in accordance with Regulation IEC 193.

An overhead crane with a lifting capacity of about 10 tones will be installed for the maintenance of electronic equipment.
The accessories will include

- Lighting System
- Lightning rod protection system
- Earthing system

At the outlet of the pipeline there will be installed a tight flight sluice hydraulic-electrical protection as with the conditions prevailing at the location.

Table 5.3: The technical characteristics of the project

The technical characteristics of the project	
Average annual supply	13 m 3/sec
Expected Annual energy production	15 GWh
Drop height	15 m
Watershed	590km2
Total annual volume of water	410x106 m 3
flood frequency	1/50
Number of turbines	2
Type	KAPLAN Double Regulator(Electronic-hydraulic turbine –governor, elastic coupling)
Speed	428 rpm
Per turbine flow	14 m3/sec
Voltage	6 KV
Power	1730 Kw
Rate	50 HZ
Maximum hydraulic losses	5%
Other losses	1%
Road works	
Length	150 m

Equipment	
Lifting capacity of electric overhead bridge	10 tones
Groove abduction	
Drop pipe	
Number	1
Allowable head loss in the penstock	1%
Diameter	2,5 m
Average wall thickness of pipe (duct)	9,65 mm
Power line	
Network Type	Core network
Length	-
Voltage	20KV

5.8 Costing of Electromechanical equipment

One of the most important elements on the recovery of a small hydro-power plant is the electromechanical equipment since the cost of the electro-mechanical equipment (turbine, alternator and regulator) means a high percentage of a small hydropower plant budget (around 30% and 40% of the total sum). This could directly influence the project feasibility (Fig.5.3)

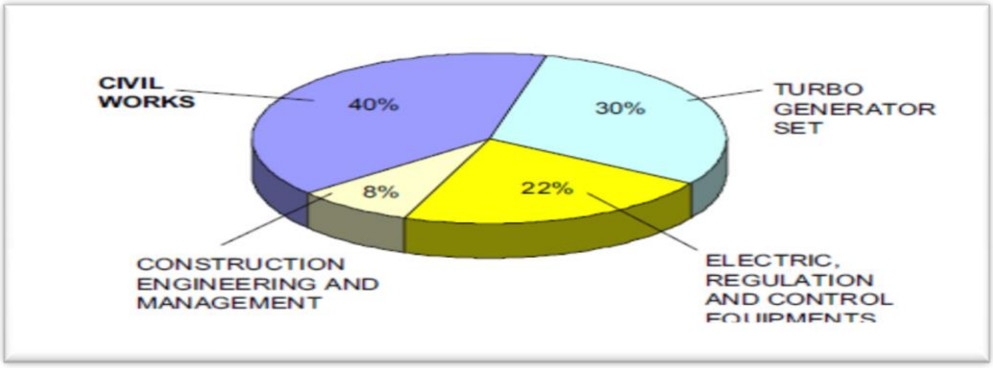


Fig 5.3 :Distribution of investments on a hydro-power plant.

Source : Vidal ,2009

For the determination of the cost of the electro-mechanical equipment, there are graphs which refer to a distant time period. But usually manufacturers of turbines and alternators do not supply any information about cost, since every installation is different and complex.

The planned investment will require the following briefly described investments into main and auxiliary units:

- Turbines (2) Kaplan Double Regulated closed type.
- Hydraulic control unit and hydraulic valve block,
- Racks to hold the leaves and sediment at the entrance of the mountain catchment, and the cleaning mechanism.
- Three-phase generator, transformer secondary voltage, low voltage transformer, electrical installation, lightning,
- Testing facility

Still there will be earthmoving works, foundations of drilling clampers, pipe coating after installation, excavation of building enclosure design etc while we will need reinforced concrete for construction of water supply and the clamping spreader pipe. Also, there is a compilation of studies and supervision of the execution of the project, as well as linking the station to the medium voltage grid.

Table 5.4: Costing of electrical equipment

Costing of electrical equipment	
Description	Cost
2 pc KAPLAN S-turbine	
elctronic -hydraulic turbine –governor	
elastic coupling	1720352
gearbox 428/750 rpm	
synchronous -generator750 rpm	
1 pc Electrical equipment	34470
Cost for transport ,erection and taking -into-operation	5170,5
Total cost	***1759992,5***

5.9 Ancillary equipment

The auxiliary equipment includes the following:

- Installation of lighting
- Installation of fire protection system
- Fire extinguisher
- Air conditioner
- Cordless phone

Safety lighting includes device in case of blackouts. Conventional emergency lighting power supply from Public Power Corporation's compatible power plant but in case of black out it is powered by batteries located in the control center room.

The fire alarm system consists of a central fire panel and 20 fire detectors who perceive the existence of smoke and the warming over 72 Celsius. The table is connected to a siren's technical department and notify the safety of the small hydropower plant. Fire extinguishers are types CO^2 which are appropriate for use in electrical engineering spaces and show zero electrical conductivity.

The supervision of space is a closed type with televisions. The circuit includes 5 screens showing the footage from cameras that are secretly installed outdoors. The tapes are retained for 15 day in accordance with the Data Protection Authority. Another security measure is the controlled doors which lock the doors with the help of electromagnets.

The intercom in the technical department takes place with the help of wireless phones.

5.10 Costing of ancillary equipment

Table 5.5: Costing of Ancillary equiment

Ancillary equiment	
Description	Cost (€)
Installation of lighting	35630
Installation of fire protection system	41570
Fire extinguisher	10670
Air conditioner	7600
Cordless phone	6650
Total	***102120***

5.11 Maintenance

The maintenance of the civil engineering works will be done by the construction company who undertook the project and the electromechanical equipment of each company made their installation. The address of the project signs with each company a service contract for one year for the normal problem-solving and the technical department solves everyday problems which may appear.

5.12 Total cost Estimation

Table 5.6: Total cost estimation

	Cost Estimation
A. Civil engineering projects	
1.Study	40000
2.Before dams	
Excavations	21600
3.Pipeline drain	45000
4.Dam-Water inlet- Desilter -Fish entrance	
Excavations	443453
Concrete	105525
5.Station building production	
Excavations	10560
Concrete	80595
Mansory	34560
Architectural	499510
6.Sub station	
Excavations	4032
Concrete	36652
Architectural	74367
formation of the external environment	20000
Total of civil engineering projects	1415854
B.Steel structures	
1.Study	25000
2.Supply – Installation	60000
Total for steel structure	85000
C.Electromechanical equipment	1862113
D.Street access	5670
E.Interconnection with the national grid	110163
F.Cost of land	138000
Overall total	5032654

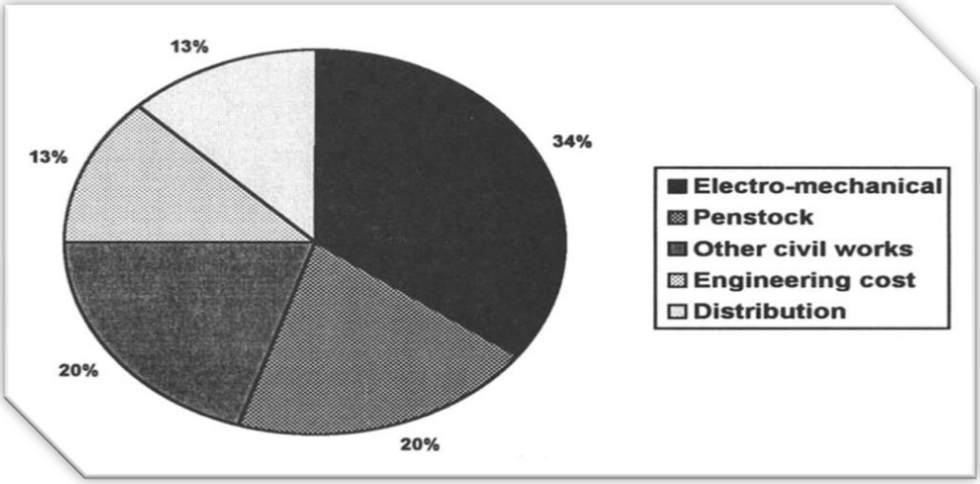


Figure 5.4: Typical cost breakdown for a medium hydro-electric project.

Source: Brown et al., 1988

Chapter 6- Organization of the establishment and general expenses

6.1Introduction

The correct operation of a unit requires proper organizational structure and programming for its overhead costs. Chiavenato defines organizational culture as a "system of meanings shared among all organization members, so that the organization may be distinguished from the rest. This has to do with the company's institutionalized way of thinking and acting. The essence of a company is expressed by the way it does business, the way it deals with its customers and employ."(Tolfoa , Wazlawick ,2008)

The separation of the company into organizational units aims to a more efficient and easier operation study of revenue and expenses of the individual business departments.

6.2 Business management and organization

The organization of the production of electricity from hydro plant is very simple, as the human resources of the company consists of 13 persons.

The functional areas of the business can be divided into (3) sections. The Directorate of Production and supply management, the Directorate of financial management and the Legal Department. Despite their distinct roles of these two addresses in a small business, the activities of each are not addressed and not standardized and processed in parallel by the same people. The production and supply management department is dealing with the planning and control of organizational functions such as the production and the supplies. Due to limited human resources of this section, this department will be responsible for more activities like quality control and training human.
The management function of the company will be handled by supporters of the investment program, who are the owners of the business. (Ceo/ Invester)

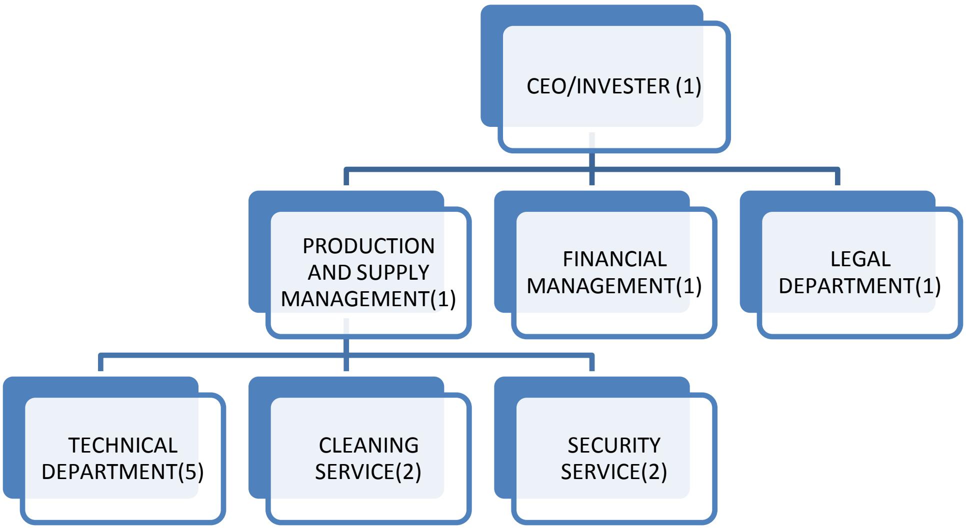


Figure 6.1: Organizational structure

The technical department will be responsible for the support and maintenance of the mechanical equipment and the control to ensure the correct and daily operation of the engineering infrastructure.

The Security Service (external partners) will be responsible for checking the site to prevent sabotage and also is responsible for the safety of the workers.
The cleaning service will consist of two external collaborators who will be responsible for the proper cleaning of the room (main building and substation) to ensure the hygienist of the workers.

The Department of Finance (1 external partner) will be responsible for the salaries of the employees and the costing and accounting management.

The legal department (1 external partner) will be responsible for writing all the necessary documents and contracts for the proper operation of the project.

6.3 General expenses

The costs of a firm are divided into two main categories, the direct and indirect costs. The direct cost has to do with the production process such as raw materials, labor costs and other expenses. The indirect costs have to do with all the other expenses not covered by the above categories.

The cost of maintenance concerns replacing any parts or components displaying malfunctioning behavior. Legal fees relate contracts that have to be made, contracts with human resources and their correctness check. Operating expenses relate expenses such as water, heating oil and diesel. The overheads 'travel' are related to the movement of manpower from the nearest town to the location of the hydropower station. The communication of the workforce is mobile unit with intercom. The safety of the businesses is total and concerns insurance from fire, natural disasters, sabotage, etc.

The technical security is an external cooperating who oversees the exterior settings preventing accidents at workplace. He will be paid 8 €/hour and he will work 24 h/d. The main concern of the company is to maintain the mental and physical health of the person. For this reason there is an outpatient facility which is equipped with all the necessary materials such as bandages, medicines, etc. The doctor who is external Partner visits the site twice a month to consider the staff or anyone who wishes. The Cleaning Service will work from 6.00-18.00 (12 hours/day) for 8 €/hour. There will be a person responsible for the collection facilities and will visit the space once a month. Overheads are presented with details in the table below.

Table 6.1: Description and overhead costs

General expenses	
Equipment maintenance	93106
Municipal taxes	60000
Legal fees	14000
Insurance	98000
Operating expenses (water ,oil)	10000
Office supplies	3600
Medicine	700
Sanitization	6000
Telecoms	2000
Trips	3000
Financial management	14000
Cleaning staff	2880
Waste collection manager	3600
Security manager	191520
Occupational physician	4800
Safety engineer	14000
Total	***521.206***

The overhead costs will be adjusted every year by 3,5 % as the rate of inflation as shown in the table below.

Table 6.2: Annual overhead cost with increments of inflation rate

Annual generl expenses (€)	
Year 1	340.546
Year 2	352.465
Year 3	364.801
Year 4	377.569
Year 5	390.784
Year 6	404.461
Year 7	418.618
Year 8	433.269
Year 9	448.434
Year 10	464.129
Year 11	480.373
Year 12	497.186
Year 13	514.588
Year 14	532.598
Year 15	551.239
Year 16	570.533
Year 17	590.501
Year 18	611.169
Year 19	632.560
Year 20	654.699

Chapter 7- Human resources

7.1Introduction

Examination of the impact of HRM policies and practices has been an important topic in the fields of both human resource management and strategic management (Becker & Huselid,1998) Theories of strategic management have acknowledged the importance of internal activities, resources or capabilities as potentially important sources of competitive advantage.

Generally there is growing evidence that human resource management practices can positively affect organizational performance (Combs, Liu, Hall, & Ketchen, 2006). Porter (1985) explicitly acknowledged that "Human resource management was an essential support activity that, when integrated with other value chain activities, is necessary for a firm to achieve and sustain competitive advantage".

Organizational culture is also an important determinant of performance (Denison, 1996) which is enhanced when employees at all levels share values, assumptions, and beliefs that are aligned with strategic goals and capabilities. The success of a business is based on people who form it and work on it, the climate and corporate culture.
After evaluating staffing needs, the company should check its budget for assess the necessary amount for payroll and personnel training

7.2 Organizational chart and job descriptions

For the correct operation of an enterprise, roles must be clearly defined and responsibilities and tasks of each being known to all. For this reason there will be an organizational chart with the names and duties of workers. Yet the duties, qualifications, experience and training of each one will be unique.

The CEO will be the leader of the project. He should have higher level of education and multiannual experience in respective departments or in some lines of production. The optimum would be he to have graduated in Faculty engineering and have additional knowledge's or masters in economics. Such knowledge is an advantage as he should be aware of the object he will deal with and control it more efficiently.

The main responsibilities of the CEO are:

a) Supervises and coordinates the implementation of the project.
b) Submit proposals and recommendations required to achieve the objectives of the project.
c) Prepare and sign contracts.
d) Decide on matters of staff in accordance with the regulations of the Personnel Rules.
e) Take all necessary measures to upgrade and utilization of staff, recommending at its discretion, new personnel regulations, organizational charts, programs, training and education.

The Director of Manufacturing and Supply has a very responsible position and should have at least 3 years experience in a similar position. The optimum would be he to have graduated in Faculty engineering and have additional knowledge's or masters in business administration.

The Department of Finance will be staffed by an outside contractor who will have knowledge of accounting, cost accounting and financial statements. He should be able to anticipate the needs of the next calendar year and organize travel expenses, research cost etc.

The legal department will be staffed by an outside contractor who will have knowledge of law and contracts.

The technical department will have 5 members/technicians which will cover the needs of the company from technological, mechanical and hydraulic point of view. They may be graduates from technological school, have corresponding previous experience and positive recommendations. They should be able to function in groups and work in a rolling schedule.

The cleaning service will consist of two external partners. One will be responsible for cleaning the buildings and the outdoor space to ensure the health of workers. On the other hand the other will be responsible for the collection of sewage and will visit the space once a month and should have a driving license. Otherwise both do not need any other special knowledge.

Security is one of the major factors in the correct operating unit electricity production. For this reason, the guard will be 24 hour per day and there will be two guards. They will switch after 8 hours. There s no need for any particular background.

7.3 Job reward

Job rewards are considered a major determinant of job satisfaction. For example, according to the equity model of Adams (1965) "people compare their input/output ratio – which reflects the rewards they receive in return for the work they perform – to that of a comparison person to determine whether they feel satisfied in their job". (Hofmans & Gieter & Pepermans 2013)

Rewards are key components of the exchange relationship between employee and employer (Armstrong, 2010; Cropanzano & Mitchell, 2005; White & Drucker, 2000). Rewards are used as a tool to guide performance in an attempt to attract and retain the best-qualified employees and keep them satisfied and motivated (Bratton & Gold, 2003).

7.4 Attracting Candidates

Attracting candidates is defined as the process of identifying and inviting the right people to meet the existing vacancies. The main objective of this process is to attract a sufficient number of suitable candidates in time and at the lowest possible cost. This can be done by:

• Notification of vacancy, in time, to appropriate sources and candidates in the most efficient manner.

• Provide information on several critical job to discourage unsuitable to apply.

Each individual company attracts candidates from either "inside" (internal sources), or the external environment (external).The new plant is expected to use the following external sources of attracting candidates:

1. Professional schools (mainly for executive jobs).

2. Career Days (or generally any conference event of this kind).

3. Internet

4. Employment Offices (OAED or private offices).

5. Professional Associations and Labour Unions

7.6 Selection of Candidates

The selection of candidates is a process of gathering and evaluating candidates for the selection of the most suitable and qualified for these jobs.

The suitability of candidates is based on the qualifications set out in the specification of each job, while the envisaged business should pay special attention to this stage, so as not to cause problems, the selection of candidates, which could cause damage to the image and to avoid improper actions and inappropriate behaviors. The steps which are intended to be followed in the selection process will be as follows:

1. **Collection and Evaluation Jobseekers:** Collection of resumes of candidates for each job.

2. **Preliminary Examination - Interview:** First interview to assess the skills and the personality of the selected candidates and general presentation of the company and the job to determine if that candidate is really interested in the job.

3. **Employment Application:** Candidates who pass fill in a claim form that includes specific questions covering the essential requirements of the job.

4. **Assays (tests):** In this phase, the company uses a number of tests, which are required to answer the candidate, such as intelligence, personality and any inaccurate, incomplete

and contradictory information learned from the curriculum, the various tests and / or from the first interview.

6. **Confirm Information about the past of the Applicant**

7. **Final Decision Selection**

8. **Offer of the Applicant:** Direct offering of employment to the candidate, taking up his duties.

7.7 Direct Salary

The system of direct payment, which would be followed by the company under study, based on a monthly payment of salary for each employee. Salaries and Bonus will be deposited in individual accounts and will be determined based on the following elements:

• The remuneration of competitors.

• The government policy and legislation.

• The cost of living.

• Conditions in the labor market.

• The requirements of each job.

• The pressure and decisions of associations.

• The strategic objectives of the business. (Dhiri Sanjay, Brand Sam)

7.8 Additional Benefits and Other Obligations of the Employer

Besides direct remuneration, the company will pay various obligations, and certain fringe benefits to all employees, which will be calculated on the total amount of remuneration under a common factor. These additional benefits and various obligations are:

• Medical and hospital care.

• Social Security.

• Private individual and / or group life insurance.

• Education (eg participation in specialized seminars).

• Educational licenses or other postgraduate studies.

• Permits general (sick, marriage, childbirth, etc.).

• Allowances (holidays, wedding, perennial, special conditions).

• Financial and legal advice and support.

• Retirement

7.9 Human Resource Programming

The table below shows the planning of human resources and their salary as they emerged from the study and design of hydropower.

Table 7.1: Workforce and annual cost

Workforce		
Skilled workers	**No**	**Annual cost**
Electrician	2	14000
Plumbers	2	14000
Cooling workers	1	140000
No skilled workers		
Guardians	2	191520
Cleaners	2	6480
Utility staff		
Doctor	1	4800
Technical safety employee	1	14000
Executive and supervisory personnel		
Ceo	1	42000
Production and supply manager	1	28000
Financial manager	1	14000
Lowyer	1	14000
Total	15	**482800**

For the proper operation of the business and the smooth integration of the staff their selection and their training should launch at least three month earlier from the operation of the project. The training will take place at the project so they can come in contact with the specific technology. This initial training will help not only in developing the productivity but also in enhancing the relations between the employees and in deepening their knowledges.

Table 7.2: Annual workforce salary costs increased due to inflation

Annual general expenses (€)	
Year 1	238.000
Year 2	246.330
Year 3	254.952
Year 4	263.875
Year 5	273.110
Year 6	282.669
Year 7	292.563
Year 8	302.802
Year 9	313.401
Year 10	324.370
Year 11	335.723
Year 12	347.473
Year 13	359.634
Year 14	372.222
Year 15	385.249
Year 16	398.733
Year 17	412.689
Year 18	427.133
Year 19	442.082
Year 20	457.555

Chapter 8-Location, space and environment facility

8.1 Estimates of needs of the new plant in places

The choice of installation space is of major importance for the operation because it as an important factor for unobstructed operation. The facilities should be adequate to cover the main building, Substation, control room, the clinic, the place where generators, transformers and turbines are located, the storage of raw materials, parking, etc.

8.2 Browse location and site selection criteria

While selecting a suitable site for a hydro – electric power plant, if a good system of natural storage lakes at high altitudes and with large catchment areas can be located, the plant will be comparatively economical.

Anyway the essential characteristics of a good site are:

- Large catchment area
- High average rain fall and
- A favorable place for constructing the storage or reservoir.
- The land should be cheap in cost and rocky in order to withstand the weight of large building and heavy machinery.
- There should be possibility of providing adequate transportation facilities so that the necessary equipment and machinery could be easily transported.

Any proposed alternative sites should provide significant benefits to the unit, advantages and incentives to act as factors of final success of the project. Building on this framework, the sitting of the unit should cover the following 10 requirements or selection criteria:

1. Availability of human resources

2. Cost of land

3. Satisfactory environmental conditions

4. Availability of transport facilities

5. Proximity to markets

6. Availability of auxiliary materials and utilities

7. Acceptance by local communities

8. Adequacy of financial, administrative and social infrastructure

9. Special services & facilities provided for by development law

10. Easy supply of raw material

8.3 Essential requirements for site selection

In each of the above criteria is assigned a weighting factor. The sum of all coefficients should be equal to 100. Table 8.1 below lists the 10 criteria with their respective weights.

As shown in the table, the most important criteria are the benefits under the Investment Law (coefficient = 20) and the cost of acquiring land (coefficient = 15)

Table 8.1: Site selection and gravity team

CRITERION		GRAVITY FACTOR
1	Availability of human resources	10
2	Cost of land	15
3	Satisfactory environmental conditions	5
4	Availability of transport facilities	10
5	Proximity to markets	10
6	Availability of auxiliary materials and utilities	5
7	Acceptance by local communities	10
8	Adequacy of financial, administrative and social infrastructure	5
9	Special services & facilities provided for by development law	20
10	Easy supply of raw material	10
	TOTAL	**100**

8.4 Characteristic features of Alternative Locations

Starting point for a preliminary rejection or selection of some sites may be the location of raw materials. The raw materials should be located near the project to reduce transportation costs.

We will examine 2 areas to see which one best satisfies the conditions and criteria defined above.

Region A: Trikala

Region B: Karpenisi

8.4.1 Evaluation of Alternative Locations

Trikala : Features on the selection criteria:

1. *Availability of human resources*

The permanent population of prefecture of Trikala is 129,700 inhabitants, (2011) and represents 1.3% (NSSG, 2001) of the total population of our country and 18.5% of the total population of Thessaly. In cluster Chasia -Antichasion, residents are mainly employed in agriculture and livestock. In the remaining lowland inhabitants are engaged in agriculture (dynamic farming, farms, greenhouses, etc.). The majority of residents of the city of Trikala is engaged in providing services (trade, services, small and medium industries, construction, etc.), a large part of those working in the industries of the region. Survey PAEP in Trikala showed that in April 2004 the unemployment registers OAED 8,714 unemployed were registered of which 38% male and 62% female. Based on this number the county is in fifteenth place among the prefectures of Greece.

2. *Cost of land*

The cost of buying amounts to 1.100€ per acre.

3. *Satisfactory environmental conditions*

The climate of the county Trikala, has clear characteristics of continental, with annual thermometer range top and 22 ° C. The average annual temperature in the lowlands is between 1617 ° C. The summers are extremely hot. Rainfall is influenced by the arrangement of mountain and lowland parts: in the western mountainous the annual amount of rainfall reaches more than 1,200 mm, while in the lowlands between 400 and 600 mm

4. *Availability of transport facilities*

The zones very close to the highway Athens - Larissa and the railway line is also very close.

5. *Proximity to markets*

2,5km from Trikala.

6. *Availability of auxiliary materials and utilities*

Trikala has waste treatment plant, pollution control laboratory environment. It also has electric and telephone network.

7. *Acceptance by local communities*

There are many hydro plant in this area.

8. *Adequacy of financial, administrative and social infrastructure*

The city of Trikala with numerous administrative and financial services is located nearby.

9. *Special services & facilities provided for the development law*

- 50% subsidy or grant of lease or grant of employment cost

- 100% tax exemption

10. *Easy supply of raw materials*

Larisa , Thessaloniki

Karpenisi: Features on the selection criteria:

1. *Availability of human resources*

The permanent population of Karpenisi is 13,500 inhabitants.

2. *Cost of land*

The cost of buying amounts to 700-800€ per acre.

3. *Satisfactory environmental conditions*

The altitude of each subregion affects the climate, which is generally characterized by cool summers and rich in rain and snow fall and winter. The climate is not conducive to the cultivation of susceptible species and high temperature or long-term vegetative plants and trees.

4.*Availability of transport facilities*

Very close to the highway Athens – Lamia-Karpenisi5. Proximity to markets 15 km from Karpenisi.

6. *Availability of auxiliary materials and utilities*

Karpenisi has waste treatment plant, pollution control laboratory environment. It also has electric and telephone network.

7. *Acceptance by local communities*

Projects relating to renewable energy is a form of development that someone needs to look carefully adapting it to their own characteristics, protecting their unique natural environment and tourism-oriented development the desire. Evrytania already offers in the national effort to develop renewable energy for many years sacrificing lands and villages but can contribute today to the extent permitted by the peculiarities of the natural, urban and cultural environment of the region, taking certainly account the wishes of the local community.

8. *Adequacy of financial, administrative and social infrastructure*

The city of Karpenisi with numerous administrative and financial services is located nearby.

9. *Special services & facilities provided for the development law*

- 40% subsidy or grant of lease or grant of employment cost

- 100% tax exemption

10. *Easy supply of raw materials*

Athens ,Thessaloniki

Table 8.2: Percentages and amounts of regional aid (Source: Article 4 / Development law)

Regions	**Belts**	**Large companies**	**Midsize companies**	**Small/micro enterprise**
Karpenisi	C	20%	30%	40%
Trikala	C	30%	40%	50%

Each of the 2 alternative sites evaluated for each of the 10 criteria and requirements-rated. The scoring is made out of 10 and should be consistent with the tiered descriptive analysis of the data of 2 areas which preceded it. For each region and for each criterion is calculated by multiplying the score in the criterion weighting factor. The sum of the scores for the 10 criteria gives the final score of each region. The results of the weighting and scoring 2 alternative locations are presented in Table 8 .3.

Therefore the most suitable location for the installation of the hydro plant is the region of Eyrytania/Karpenisi.

Table 8.3: Evaluation of alternative sites

	CRITERION	Gravity factor	Region of Trikala	Region of Karpenisi	Region of Trikala	Region of Karpenisi
1	Human resources	10	8	6	80	60
2	Cost of land	15	5	8	75	120
3	Environmental conditions	5	8	9	40	45
4	Transport facilities	10	8	9	80	90
5	Proximity to markets	10	8	8	80	80
6	Auxiliary materials and utilities	5	8	8	40	40
7	Acceptance by local communities	10	8	8	80	80
8	Financial, administrative and social infrastructure	5	8	8	40	40
9	Development law	20	10	9	200	180
10	Supply of raw material	10	8	9	80	90
	TOTAL	**100**			**795**	**825**

8.5 Selecting the installation site

Evrytania is one of the regional units of Central Greece Its capital is Karpenisi and is part of the mountainous region of southern Pindus. The census of 1971 charged the county area of 2047 sq. and now reduced to 1,874,000 acres. (broken down as follows:

850,000 forests, pastures 754,370, 90,000 agricultural land, lakes 88,000-rivers, villages-roads 91,000 acres).

Evrytania is the most mountainous region of the country, with an altitude of 550 to 2315 meters and forest cover almost 50%, while the corresponding figure for the whole of Greece is 19%.

North of Karpenissi rises Veloychi (Timfristos) and spread the sprawling massif Agrafa. South extend two mountain ranges, the first consisting of Kaliakouda and Chelidona and second south, consisting of Oxia and Panaitoliko at the boundary with the mainland. The rivers Megdovas, Agrafiotis Trikerioti, Krikellopotamos were born by the snow in the mountains, Agrafa , Velouchi and Kaliakouda. Later they meet with Achelous. Lakes were created in the north Plastira ,Agrafa and the artificial lake in the southeast Kremasta. The mountains from spring to autumn are ideal for climbing and hiking, while the rivers are ideal for crossings, rafting and kayak, even swimming. Comprehensive, high-quality infrastructure, houses, taverns, bases activities, riding, created in many villages, so one can 'comfortably enjoy the pleasures that nature offers.

Figure 8.1: Map of Evritania

Source: http://en.wikipedia.org/wiki/Evrytania

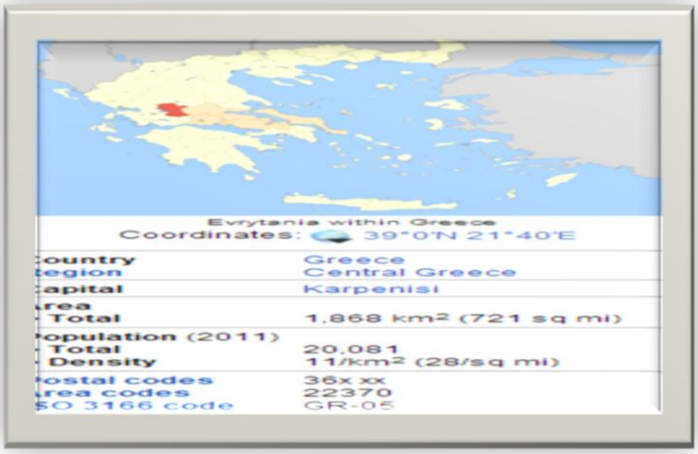


Figure 8.2: Evrytania within Greece

Source: http://en.wikipedia.org/wiki/Evrytania

8.5.1 History

Evrytania dates to ancient times (around 6000 to 5000 BC). Evritania played a very important role in the historical development of our country. Whenever life became difficult in the valley, the mountains provided Evrytania shelter of the lofty warriors. In the 2nd century BC it fell into Roman hands, and became part of the Roman province of Macedonia. In the 3rd century it became the Byzantine Empire. In the byzantine era Evrytania have to show many Christian monuments. In 1204 it became part of the Despotate of Epirus, which was conquered by the Ottoman Empire around 1450. Evrytania became better known during the Ottoman and '21, when the whole nation gained their freedom and national independence after four hundred years of slavery. In Evrytania appeared and acted the first guerilla fighters and thieves. Unlike other parts of Greece at the time which were definitively ruled by the Ottomans, the area around Agrafa managed to sustain complete autonomy. After 400 years with the Greek War of Independence Evrytania finally became part of Greece As in all of Greece, the area was affected by World War II, and later the Greek Civil War. Its economy expanded at the end of 1940s but there was significant migration from the villages to cities.

8.5.2 Geography

Evrytania is almost entirely formed of mountains, including the Tymfristos and the Panaitoliko in the south. Its rivers include the Acheloos in the west, Agrafiotis to the east, and Megdova in the east flowing down to the Ionian Sea. It is one of the least populated regional units in Greece. The area borders Aetolia-Acarnania to the west, southwest and south (west over the Acheloos river), Karditsa regional unit to the north, and Phthiotis to the east.

8.5.3 Transport

The Greek National Road 38 from Agrinio to Lamia passes through the southern part of Evrytania and the town Karpenisi. On the border with Phthiotis, the GR-38 passes through the 1.4 km-long Tymfristos Tunnel since 2004.

8.5.4 Tourism

Evritania a rapidly growing tourist area with significant infrastructure, located in the mountains of central Greece. The number and quality of infrastructure, be it luxury hotels or hostels traditional friendship, or business dining and entertainment are an important tourist infrastructure that can accommodate even the most demanding guests. The tourist infrastructure of the region combined with an environment of natural beauty have classified among the most important winter destinations of our country. It is hard to find, another Greek winter destination that has just 12 km away from the city, developed ski resort, with even roads, 1500 more beds to be accommodated.

The sports tourism, congress, loving, religious and general alternative forms of tourism are with winter tourism spearheading the development of tourism in the region. (http://www.evrytania.gr)

At the foot of the famous mountain there are the rivers Acheloos, Agrafiotis ,Megdovas ,Trikerioti , Krikellopotamos etc.,which run by creating a distinctively beautiful mountainous landscape, rich in flora and fauna.

Tucked tightly over their traditional villages, settlements and farmsteads incredible beauty in the most unlikely places, marking the first video. Old stone paths, which still pressed, in a wisely designed with economy forces, communication network, arched bridges, shrines, threshing floors, many churches and monasteries .

From the region passes the European path E4 ("Network NATURA 2000"). [The route: Vrangiana, Tridentro, Agrafa, Varvariada, Krenti, Kerasohori, Viniani, strictly Ai Thanasis Karpenisi Karpenisi, Kallithea, Myrica, Krikello, Stavropigi

At the same mountain walksin mountain and I rivers give an unforgettable experiences. (Velouchi skiing, climbing mountains and hiking the old and new paths beside the river, visit the beautiful natural monuments "Pantavrechi", the "Black Cave" Agrafa etc., but the paths to Hanging lake and rivers with canoes and kayaks or beside them with 4x4, provide unlimited opportunities in the region).

8.5.5 Fauna

The fauna of the mountains in Evrytania is still very rich and still dominates, despite the extensive forests of firs, oaks and oxyon that have been reduced. Evrytania remains a valuable refuge for large mammals in the region reside boar and many of the medium and smaller mammals of the country. The wolf arrives here in the southern part of its range in the Balkans. Someone can see: wild boars, wolves, wild cats, weasels, ferrets, a few deer, foxes, rabbits and many other smaller animals in the animal chain. In the rivers of the region with the crystal-clear waters, there are some kinds of fish such as Glynos, carp, the priana, perch. (http://www.evrytan.gr/)

8.5.6 Soil and climate data.

The main mountains of Haryana is the south Pindus Mountains, continuing with the Timfristos, the Chelidona, the Kaliakouda and Panaitoliko, mountains, lush forests and steep ravines. Generally the soil is steep terrain and steep gradients, which result in the characteristic phenomenon of intense landslides of loose rocks and flysch shales above the solid background. The area of Haryana is located in the geological zone of Pindos, which forms the spine of central Greece. The rocks that compose it have direction from north to south; same address and have multiple cracks running through it.

The rocks that make up the region are: Trinity limestone, platy, Jurassic limestones, shales and cherts with typical shales conformation etc

Underground water horizons are not formed, because the thickness of the alluvial deposits is insignificant; rather abounding the sources, both within the karst limestone and sources of limestone, ensuring the water supply of cities and of villages of the county. The climate of the area is mountainous, harsh winter with lots of rain and cool in summer

Soil erosion and large numbers, created numerous canyons where the major rivers flow through, Acheloos, Agrafiotis the Megdovas the Trikerioti the Karpenisiotis and Krikelopotamos. In the open basin that formed southwest of Haryana, the intersection points of these rivers, created large dam (Katsantoni) Kremaston, the namesake pond and Ydrilektriko Station (HES) PPC.

The nature of rock, large gradients of soil and heavy rainfall, were major causes landslides and forced movements in many villages. The altitude of each subregion affects the climate, which is generally characterized by cool summers and rich in rain and snow fall and winter. (It would not be out of reality to say that Evritania readily discern only two seasons, winter and summer). The climate is not conducive to the cultivation of susceptible species and high temperature or long-term vegetative plants and trees. (The main chestnut and walnut can be considered favored for cultivation here).

The subsoil of Evrytania has not been under systematic research, although it is believed that in the areas of swallows and Karitsa areas are undetermined amount of copper. Also among Granitsas and Monastiraki and Proussos there are speculations that mineral oil exists.

8.5.7.Rivers

The river ***Trikerioti*** , is formed by joining the waters of Krikelopotamos and Karpenisiotis. Trikerioti follows his own fluid path, between towering narrow canyons with overhanging cliffs and green banks with lush vegetation. The aquamarine waters enhanced by water veins that descend from the surrounding mountains towering Evrytania.

Figure 8.3:Trikeriotis

Source: http://eyrytixn.blogspot.gr/2011/07/blog-post_10.html

The river ***Karpenisiotis*** flows from the western slopes of Tymfristos and flows southwest where it joins the river eventually forming ***Krikelopotamos*** River Trikerioti. Its length is 15 km. The Karpenisiotis while flowing southwest crosses the valley between the mountains Kaliakouda and Helidona. The vegetation which dominates the mountain slopes are composed of deciduous broadleaf trees. Around the river there are several villages of Evrytania who know tourism development in recent years like the Grand Village and Small Town.These two streams coming together to Dipotama of Prousou, gather the waters of South and Southeast Evrytania. They are quickly - and with inclination - rivers, with Alpine type passes. Throughout most of their journey they erode the steep and impassable gorges from where pass.

Figure 8.4: Geographic features & Photographs around Krikellopótamos, in Greece

Source: Google map

Trikerioti River, formed by Krikelopotamos and Karpenisiotis passes the Agalianos (Acarnania now). The constant speed and the famous rock garden creates a suspenseful scene fluid.

The project is scheduled to be constructed in the river Trikerioti which begins after the union of the rivers Krikelopotamos and Karpenisioti in the bridge position Geromporou on the country road Karpenisiou - Prousou.

8.6 Description of the installation environment

- ✓ In the study area the natural environment consists of agricultural area owners.
- ✓ There is no air pollution because movements by means of transport is limited.
- ✓ There is no any cultural or historic environment in this region.

8.7 Assessment and environmental impact assessment

This specific project:

1. Will not alter the climate characteristics of the region
2. Will improve the climatic conditions as it will replace some of the energy that would additionally produced by other conventional sources.
3. Will reduce the pollutants that create the greenhouse
4. Will not cause geological provision of the area
5. Will not cause danger to any people from earthquakes and landslides
6. Will not cause changes in biodiversity in flora and fauna.
7. Will not affect the lives of animals and fish
8. Will support the tourism sector in the region as the reservoir will be an artificial lake
9. Will improve and increase investment intentions from locals and non-local investors.
10. Will have a positive impact on the quality of the local's life.
11. Will provide new jobs.

8.8 Basic studies to address the environmental impacts

Building a dam and an artificial lake cause disruption to the natural environment because and due to the accumulated water, pressure is build in the subsurface. The water except from the humidity and pressure ,it creates and landslides.

To avoid all these we will:

- We will make a sufficient geological analysis
- We will make a sufficient static and seismic study

- We will take into account the weather.

These projects will be undertaken by a civil engineer with the help of a geologists and a topographer. Micro-hydro projects are usually installed by one or two engineers ,supported by technicians and local labour, which must have multi-disciplinary skills such as project planning, management, surveying, structural, mechanical and electrical engineering, economics, marketing, negotiation and administration.(Smith,1994)

Engineers traditionally evaluate costs of building, operating and maintaining water supply, conveyance, storage, sewerage, drainage, and waste-water reuse infrastructure and estimate water requirements.

Most hydroeconomic models share basic components including hydrologic flows, water management infrastructure, economic water demands, operating costs, and operating rules. Another design choice is how to represent environmental or ‘ecological’ flows. Modelers can use environmental economic valuation techniques (‘‘Environmental and recreational water demands”) or treat environmental requirements as low-flow constraints (Jenkins et al., 2004).

A typical hydroeconomic modeling study involves a base case representing current infrastructure and water management practices. Reproducing historical results is important to establish model credibility. Further alternatives and scenarios may include new infrastructure, operating rules, institutional and policy changes, changes in demands or hydrologic conditions (e.g. climate change), or combinations of these. Users then compare and contrast results for the different alternative and scenarios.

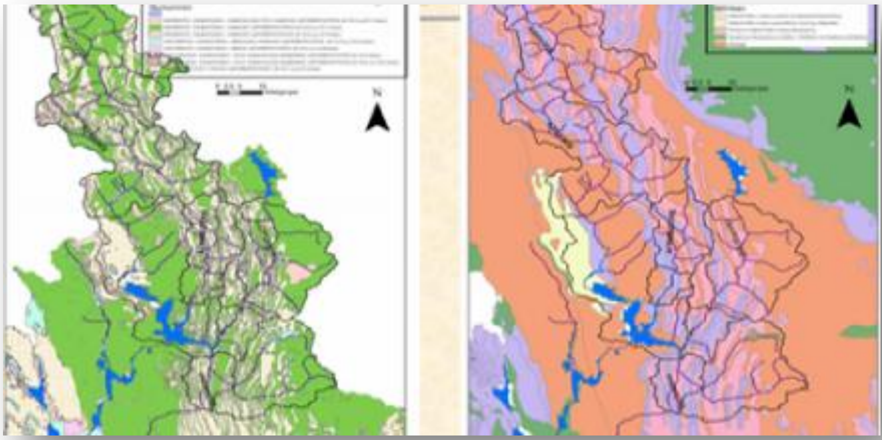


Figure 8.5: Geological analysis in Kremasta

To prevent water seepage into the subsoil to the rocky part of the dam we will do grouting with cement.

We will implement an environmental management system since the company will follow a friendly environmental policy for the conservation of natural resources and compliance with regulations. There are concurrently policy initiatives (such as the EU Water Framework Directive) to restore the multi-functionality of riverine ecosystems and landscapes (Pahl-Wostl, 2006; Sigel et al., 2010; Wolsink, 2006). Ecological goals, social policies, institutional realities and political considerations can readily be included as constraints within hydroeconomic models (Fisher et al., 2002).

The company will seek to obtain the international standards of ISO 14001 from ELOT.

As about the buildings we will construct them construct them with modern methods to prevent most of the pollutants and will develop specific policies for the transportation and the recycling of the garbages.

8.9 Financial data of the project

The calculation of the cost of the investments refers to the cost of acquiring the land, environmental and other studies which are is essential criteria of a study.

The main economic data are analyzed below(Table 8.4)

Table 8.4: Initial financial data of the project

Study	**40000**
Cost of land	138000
Legal fees	14000
Total	192000

Chapter 9- Time scheduling of the investment program

9.1 Introduction

The aim of this chapter is to define and carry out all outside and inside plant work necessary to bring the project from the design stage to the feasibility stage of the operation. In this way we will establish a schedule under which the group will supervise the project in order to start the operation .Additionally, we define costs and the corresponding activities to be held in pre-investment period.

The implementation phase of the project includes the period of the investment decision until the commencement of commercial production of the unit.

If there is no good planning, this stage can be extended over a long period so as to jeopardize the entire financial operation of the program.

The planning phase for the investment in question is a difficult process, and in part on the licensing process works on Renewable Energy Sources (RES) observed problems, which prevent the exact timing of the completion of any necessary action as the start commercial production of the unit. The main problems in the licensing process is both the fragmentation and complexity of this process and also the highly subjective nature of the evaluation license applications.

The technical part of the investment is not a problem, as it is possible to calculate the exact time at which it is processed.

The following section relates to the detailed presentation of the token, institutional and financial framework for the implementation of RES projects in Greece and especially of investments in Hydro Plant.

In this context, programming and budget execution of this project will include the following key steps:

• Determining the type of work inside and outside the premises, which are necessary for the execution of the project.

• Define the logical sequence of events in the work of the project.

• Prepare a timer program execution of the project, which be displayed correctly in time, the various tasks and are suitable periods for completion.

• Determine the resources required for the completion of each job and report the corresponding costs.

• Prepare a budget for the operation and status of the project cash flows, which will ensure the availability of necessary funds, during the execution phase of the project.

• Documentation of all elements of project execution, which allows time and financial planning and scheduling of the predictions made in previous phases of this study.

9.2 Small hydro projects - the steps of a study

9.2.1 General

The study of a micro / pico hydro plant includes several phases, the extent and depth of which depends significantly on the nature and size of the installation. These phases fall into three categories, namely those that are and studies required for the completion of a hydroelectric project.

9.2.2 Types of studies

We have three stages we have to follow:

- ❖ Feasibility study
- ❖ Premeditation installation study
- ❖ Final study

First is the ***feasibility study***. The purpose of this study is to ascertain whether the test position deserves more investigation. This study includes the following:

- Determine the height of fall, with an initial intake siting and location of the station production.

- Mapping term supply position, to estimate the annual energy production and calculate the annual revenue of the project.

- Estimated construction cost of the project based on the morphology of the area, the length of the penstock, the type of electromechanical equipment and distance interconnection with the grid.

- Determining the economic viability of the project, calculating the necessary economic indicators and conclusions.

If the result of the feasibility study prove positive and he wants to launch a project, then comes the ***premeditation installation***. The purpose of this study is to develop and design the project, as shown by the examination and analysis of various alternatives. The level of analysis of premeditation is such that it is sufficient for the issuance of various permits required to construct the project. The design and which is based on the results of the feasibility study include:

- Selection of turbines, and the determination of hydraulic characteristics.

- The choice of generators with their characteristics and all subsequent electrical equipment.

- Defining characteristics of the automation system and operation of the facility.

- Down the system flow of water in the channel, namely the abstraction, the duct, open or closed, the reservoir charging and other ancillary facilities.

- Building infrastructure for the installation of mechanical equipment with layout of turbines - generators for easy access and maintenance without interrupting the operation of other units, automation and all auxiliary equipment, substation, and interconnection to the grid.

If the result of premeditation plant is positive, then it is no longer the ***final study*** of the plant, which compiled all drawings, calculations, the results of the economic analysis and the specification of the necessary equipment, as well as the environmental impact study. By the end of the study setup, now begins the construction of the project.

9.3 Procedures for the inspection of micro / pico hydro installation

This section details the steps to be followed for the study of micro / Pico hydro installation. We have to mention that the extent and depth of each step depends heavily on the nature and size of the installation.

Step 1: Identification of the region

The identification of the site includes the original layout and location of the project, the recording of local conditions, difficulties, infrastructure, other competing uses of water and the study of geological conditions.

Also someone must determine whether there is demand for electricity in the region, potential consumers / customers and whether they are available or not an external power grid.

Step 2: Collection of existing hydrologic data

Collected and evaluated existing hydrological data and plotted lasting benefit. When there are no adequate hydrological data (the usual case), is approximated those considering data from this basin from neighboring basins, and comments and observations from local residents.

Delaying hydro projects for several years, in order to obtain accurate flow data, is sometimes inconvenient. Inversin, 1986 said that" it may be possible to obtain quite accurate flow duration information, with just a few measurements, by correlating the flow for the river or stream of the hydro site with data from a gauged river or other hydro site in the same general area "(Inversin, 1986).

Step 3: Market research and Availability

At this stage it is not yet possible to complete technical and economic analysis of the installation. It becomes simply a market survey on the cost of the turbine, the generator, the controller of the generator and the pipes of the installation, since they will definitely the most expensive elements.

Step 4: Calculate the power output

According to the possible combinations of hydraulic heights and benefits that can be achieved by calculating the output wattage of the facility and whether it is sufficient or not to operate a micro / Pico hydro plant. The power plant is calculated by the following formula:

$$P = Q * H * \eta_h * \rho * g \quad [W]$$

Where:

Q	discharge	$[m^3/s]$
H	gross head	[m]
η_h	hydraulic efficiency	[-]
ρ	water density	$[kg/m^3]$
g	acceleration of gravity	$[m/s^2]$

The efficiency depends on the level of the losses which depend on the construction of the water passage of the turbine. However, the design of the runner is just theoretical. This means that the runner is not designed for a specific plant and the water passage does not exist.(Flaspöhler,2007)

The calculation with the formula above is approximated. Considered, i.e., a total efficiency of the plant (a value in the range from 55 to 75% is pretty close to reality), and then with the known values of flow rate and height, calculate the output wattage. It must be stressed at this point that the total efficiency of the plant depends on the efficiencies of the individual components that compose it.

The data is usually available in the calculations is the nominal efficiency of the turbine and the nominal output of the generator and the transformer, so it can calculate the total nominal efficiency of the installation.

Step 5: Calculate installation requirements

It is estimated that the minimum electrical power to be generated by the generator of the plant to operate at the desired level of all devices that are designed to connect and replenish it.

Step 6: Size and cost generator

Depending on the installation requirements calculated in the previous step is selected the size of the generator and then - with the help of the research was to Step 3 - calculated the expected costs.

Step 7: Preliminary test of economic viability

Depending on the assessment of the power output (step 4) and the requirements of the installation (step 5), the optimal design is chosen and compared with the annual revenue cost of capital investment.

i. If the annual income is less than 10% of the cost of the initial capital, then investment is seen as unsustainable.

ii. If revenues ranging from 10% to 25% of the initial capital, then investment is quite feasible.

iii. If annual earnings exceed 25% of the initial capital, then investment is considered as highly sustainable.

Step 8: Power supply and height

At this point, selecting appropriate combination of prices and supply of hydraulic head, to produce the power required by the system impulse turbine - generator. Also need to make estimates about the efficiency of the installation. A typical range is between 55 to

75%. If any doubt arises total efficiency (total power conversion from hydraulic to electric) equal to 45%.

Step 9: Select the final output price

We estimate the final size of the generator to be used, according to the data of the hydraulic resources and the provision of installation calculated accurately. It is noted here that sometimes it is better to keep the generator size smaller than initially estimated, although the capabilities of the installation may seem larger. This is because the cost of installation is less significantly reduced compared with that of an older and when he has made a mistake in their calculations, so far, it is easier to fix.

Step 10: Planning the installation

We check all the manufacturing plans ,the installation and all the components of the facility, their dimensions and their arrangement, the lengths of the pipe, the water channels and their locations, the building of the plant, etc.

Step 11: Alternatives

This step is checked whether any alternatives - in system design - could lead to lower costs or better service. For example placing a water pipe to another location might reduce its length, which means lower costs. This step may lead to the relocation of pipes, channels, building the unit and generally every element of the installation.

Step 12: Detailed cost estimate

We estimate the cost of each item of micro / Pico hydro facility and then we have the total initial cost. The cost of each item is good to grow at a rate of around 5%, so to cover any unforeseen expenses arise.

Step 13: Testing economic viability

Under the new price of the cost of installation, which resulted from the previous step of the design process, we will calculate if the investment continues to be financially viable. If not, it elements of the installation that caused the additional financial burden must be changed (e.g. water pipes, cables, etc.) with new cheaper.

Step 14: Order materials, necessary equipment and installation

Plus, it can make the ordering and receipt of materials and generally the whole necessary equipment for the operation of the project. The elements are ordered based on the calculations made in the previous steps of the design process and installed in accordance with the system design.

Step 15: Training of staff

When starting a new hydro plant the initial emphasis should be placed on staff training and organization of financial assistance. The following points are recommended for guidance:

1) Address technical, social, management and financial issues are before the project starts.

2) Employ at least one engineer with previous micro-hydro experience.

3) Design carefully the scheme.

4) Use locally available and proven equipment as far as possible.

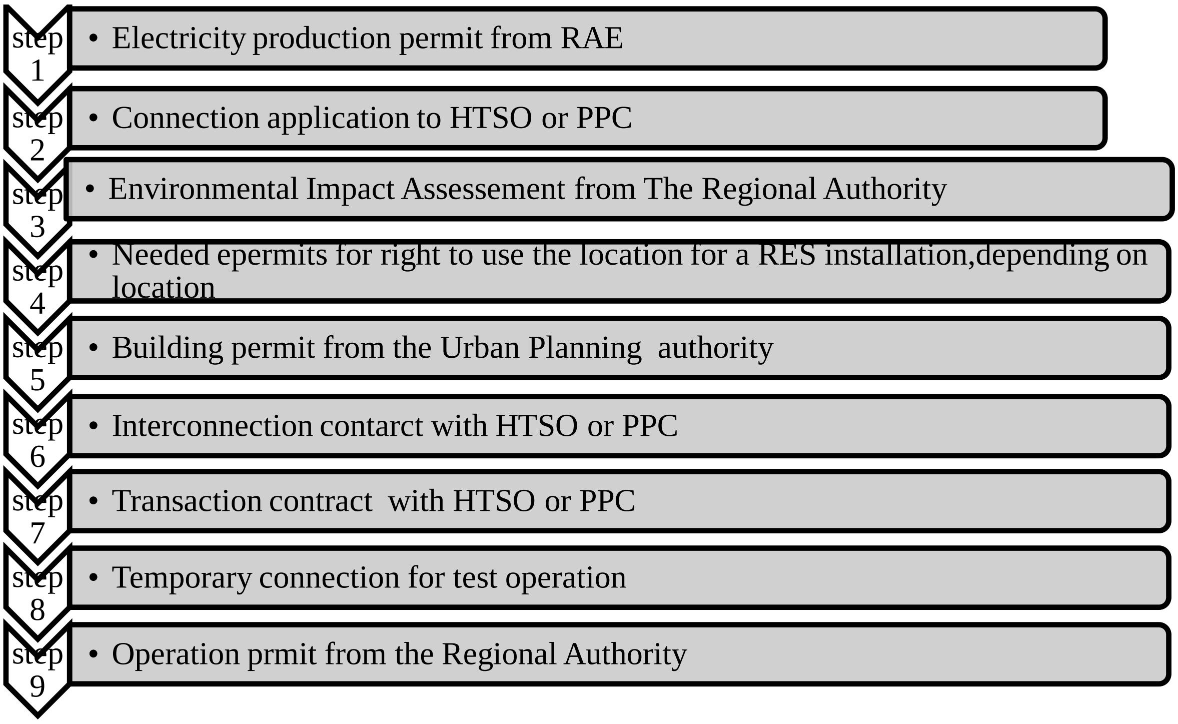
If imported equipment is required, then ensure that it is purchased from a reputable supplier and that full documentation and spare parts are provided. (N.P.A. Smith, 1994)

Step 16: Commissioning

After being checked for proper installation and connection of all components, turn on the unit.

9.4 Authorization and installation of hydro plants

Figure 9.1: An overview of the licensing procedure for RES in Greece



Source: http://enermed.cres.gr/Permitting_Procedure

The documents and studies and general steps required for a small hydroelectric power plant are:

1.Publication of electricity production license (RAE)

2. At the same time other applications we should do are

- ✓ Making a connection offer the power plant to the system or network (PPC or TSO)
- ✓ Environmental Authorisation (Region)
- ✓ License intervention in forest or woodland where required or generally necessary permits to obtain the right to use the implementation of this project (Region)

3.Simultaneously

- ✓ Issuing installation with integrated water use license forms exploiter of the project if it is a small hydroelectric power station (District)
- ✓ Issuance of building permits (where required performance construction) or other permits and approvals may be required and may be issued without further authorization facility (urban or competent authority as appropriate)
- ✓ Contract Connection system or network (PPC or TSO)
- ✓ Trial period and licensing (Region)

The above procedure differs depending on the installed capacity of the power plant, the technology used and the location.

Based on the above, for the design of the timeframe for establishing and operating the project, we will take into account the following activities, which will take place from January 2014:

1. The **study phase** will last for 6 months and consists of:

The Company Establishment

Filing of the necessary documents to the court and its approval is expected to be completed within two (2) weeks.

Obtaining a Production License

This documentation relates to the Production License Exception Taken submitted to RAE and is expected to be completed as a process within three (3) months.

Approval of Environmental Terms

This is the most time consuming process, as it is expected to take four (3) months and depending on whether they address problems, can reach up to eight (6) months.

Integration Development Law 2010

Due to last one (1) to three (3) months, depending on the workload of the local area.

Association agreement with PPC

This process is expected to last one (1) week.

Power Purchase Agreement with the TSO

Once the procedure Association Agreement with PPC is ready, we fill the necessary application for the Power Purchase Agreement with the Administrator of the National System for Energy. This process is expected to last one (1) week

Financial Arrangements

Contact with banks taking the necessary loan is expected to be immediately after the Purchase Agreement as it is now in the hands of supporters of the project document. Taking the loan is not expected to last more than a week.

Detailed design of civil engineering structures

Along with the design and the acquisition of machinery and equipment there should be made and actions affecting engineering structures. There should be detailed planning of specific projects such as:

- License installation
- Building permit
- Authorization factory
- License environmental conditions
- License management of liquid and solid waste
- License disposal of liquid and solid waste
- Permit for water (water users based registry)

Recruitment and staff training

At this stage, all operations required will take place for the recruitment of planned human resources which will be employed in the new company. At the same time stage we will be provided with skilled workers in the production of the companies such as suppliers of technology and machinery. The evaluation is based on the qualifications of candidates and interviews which will take place. Initially there will be activities which will attract candidates for permanent jobs, selects managers for the relevant sections and suitable training seminars based on the policy of the company will be organized.

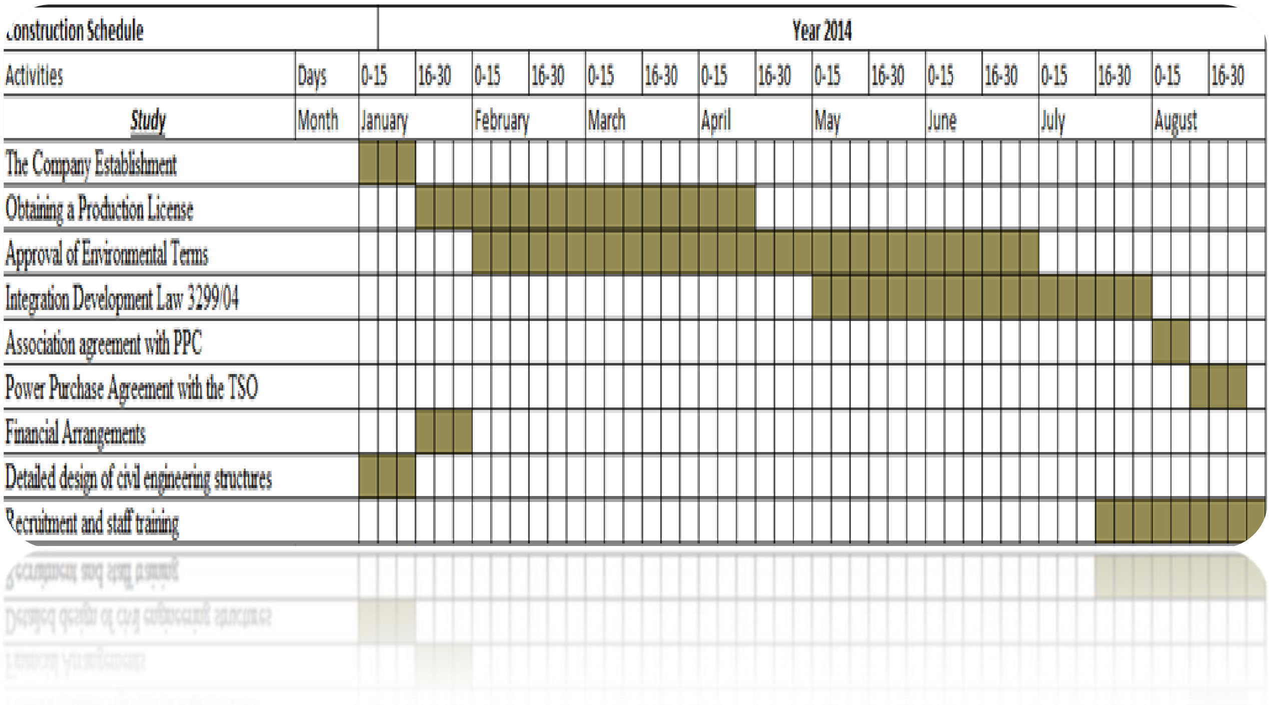


Figure 9.2: Gantt chart for the study phase

2. Construction of the unit

The duration of work is expected to be as in the Gantt chart below. The realistic implementation planning of construction projects and the installation of mechanical equipment are highly important part of the implementation of this project. This lies in the fact that any delay during the construction period will have a direct impact on cost and revenue projections made in the present study. So, at this stage someone should have sufficiently prepared the installation space and make all necessary provisions and civil engineering work, with particular attention to the definition of the range of projects and construction activities. This determination should be made in relation to the requirements of infrastructure and program arrival and erection of various parts of machinery.

In this part we also have to construct the Roads of the SHP.The SHP require two kinds of roads. Permanent access to water supply and to the plant.

a.Road access

There is no requirement for special roads. The usual forestry and rural roads in the Greek countryside are sufficient for the access of the SHP. In most cases and for reasons of traffic throughout the duration of day it may be required extensive improvements and coating material to facilitate the passage over the winter period.

b.Road Construction for piping installation

In the absence it is required an opening of a new road for the positioning of tubing. In most cases the roads that are drilled are simple worksite roads (in the forest or rural roads) of sufficient size for the passage of the machines which are involved with the installation of tubing (trench excavation etc.) (Asimakopoulos, 2007)

3. Acquisition and Transport Technology of Equipment

Along with the necessary applications for inclusion in the Development Law 2010 we will take the necessary steps to acquire the equipment. The duration of work is expected to be four to five months.

4.Testing and commissioning

The two latest months the plant will be in use to test its operation.

On the next page there is a Gantt chart, which gives details of the timing of the completion of the hydro plant.

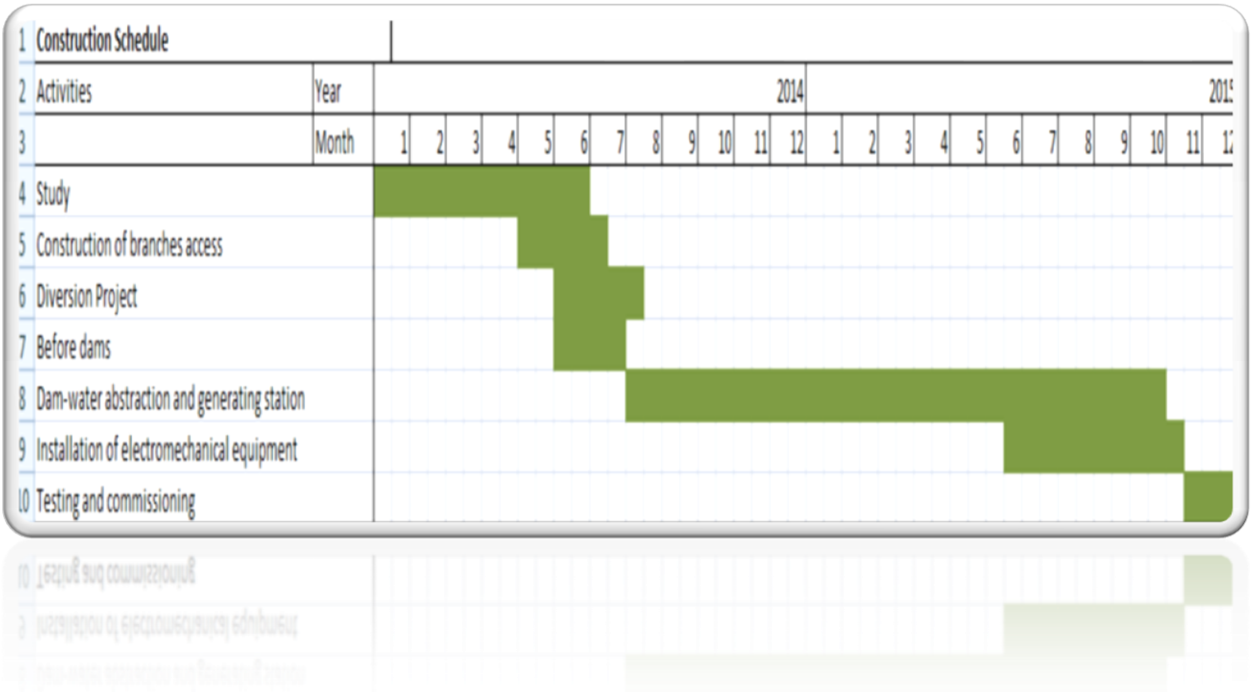


Figure 9.3:Gantt chart of the construction schedule of the hydro plant.

9.5 Estimated Cost of Program Execution

The aim of the budget costs of operation of the project is to determine the resources required for the execution of the project, having taken the decision to implement it.

Consequently we should determine the cost of these funds until the time of commencement of operation of the unit, taking into account the timing of the execution stages of the project, as described previously. The estimated costs of operation are part of the total investment cost.

On this basis, the table below presents the estimation of the investment costs, in terms of program execution:

Table 9.1: Cost estimation for setting up the small hydropower plant

DESCRIPTION	Cost(€)
Performance management program	5.000
Cost of incorporation and obtaining permits	15.000
Detailed engineering drawings engineering	20.000
Supervision, coordination and control engineering and machinery	25.000
Transport of technology	5.170
TOTAL	70.170

The cost of incorporation includes expenses directly associated with the establishment of the company, as finance charges, fees and taxes, fees paid for services attracting executives and various communication costs.

The cost of detailed drawings of mechanical equipment and civil engineering works includes consultancy fees, the cost of soil testing, printing drawings and specifications, and the cost of rent and operating offices and cars.

The cost of technology transfer includes travel, communication, and consulting fees.

Chapter 10- LCA of the Small Hydro plant

10.1 Introduction

Energy and environmental problems are related each other and needed to discuss comprehensibly. For the solution of these issues, the utilization of renewable energy becomes the target of global attention. Hydropower must become "cost-advantage" and "environmental friendly". (Shimokawa, Furukawa , Okuma , Matsushita ,Satoshi Watanabe ,2012)

Electricity is the only form of energy, which is easy to produce, transport, use, and control. Electricity consumption per capita is the index of the living standard of people of a place or country.

A hydroelectric power plant uses a renewable source of energy that does not pollute the environment. Hydroelectric power plants are very useful for limiting the emission of green house gasses from power generation plant, as energy becomes the current catchphrase in business, industry, and society, and energy alternatives are becoming increasingly popular (Majumder,Majumder, Roy, and Mazumdar)

The energy sector, especially of developing countries, poses serious challenges to the policy makers. On the one hand, they face financial and technological constraints in their efforts to add new energy capacity. On the other hand, the rising global concerns for environment have enormous implications for their economies (Sahir and Qureshi, 2007).

In this chapter we will fulfill a Life Cycle assessment of the hydro plant.LCA today is being used for decision support. With LCA, there is no feedback mechanism. Here, confidence in outcomes can be based only on the quality of the input data and the quality of the models used. For the acceptance of LCA results, it is crucial that the level of confidence is appropriate for the decision to be made. Currently, no general method exists for establishing the level of confidence in LCA results.

10.2 Goal and Scope Definition

The *goal* of an LCA entails the deliberate application, the reasons for the study and the audience to which we actually address. In our situation, the goal of the study is to assess the environmental impacts of The Hydro plant.

The *scope* of an LCA analysis defines the methodological choices of the investigator, the function unit, the function of the system and its boundaries and our sources. Our functional unit was defined as 1 KG of each material.

The *system boundaries* will be presented for each material below. As far as the geographical coverage is concerned the study was expanded and contains the transportation of the recycled materials back to the plant.

The results of input-output of each stage were analyzed and the environmental impact assessment was created using the principle of conservation of mass. Particular attention is also given and the consumption of energy resources. To complete the assessment, we used the information from the Internet, from the existing literature, research programs etc.

10.2.1 General applicable data for Life cycle assessment (LCA)

A product's life cycle starts when raw materials are extracted from the earth, followed by manufacturing, transport and use, and ends with waste management including recycling and final disposal. At every stage of the life cycle there are emissions and consumption of resources. The environmental impacts from the entire life cycle of products and services need to be addressed. To do this, life cycle thinking is required.

“Life Cycle Assessment is an objective process to evaluate the environmental burdens associated with a product, process, or activity by identifying energy and materials used and wastes released to the environment, and to evaluate and implement opportunities to affect environmental improvements.”(Life Cycle Assessment of Aggregates, EVA025,2009)

It is an excellent tool that can be used to evaluate environmental performance and support decision-making in the whole value chain starting from raw materials extraction to processing, component fabrication, assembly, delivery, use, recycling and disposal. Figure 10.1 illustrates the four interrelated phases in an LCA study.

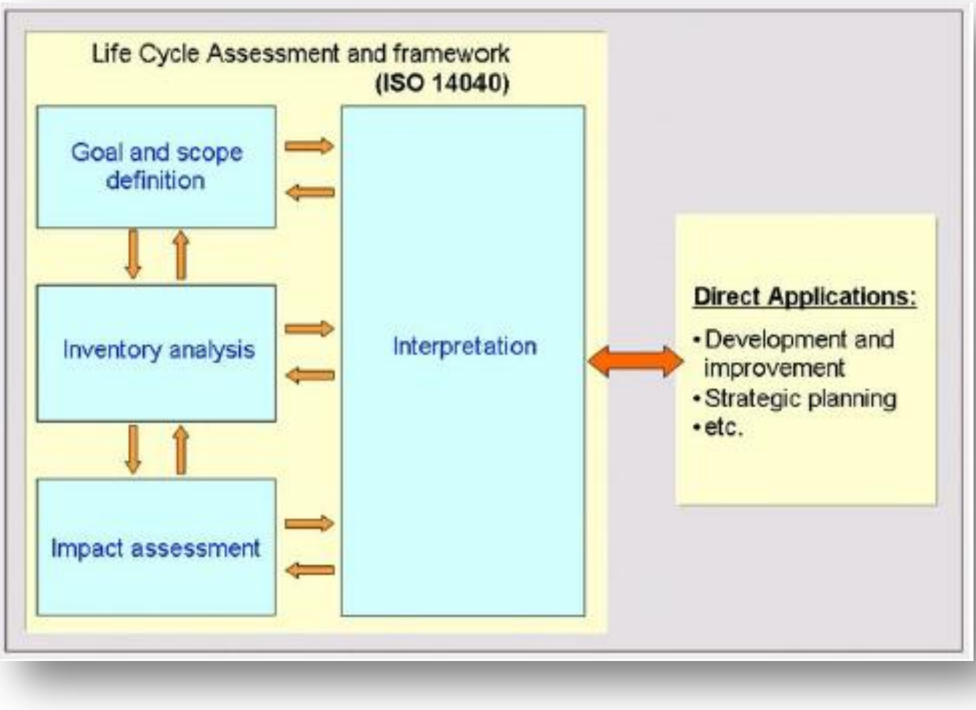


Figure 10.1: Stages of an LCA study
Source: Korre & Durucan,2009

The **main benefits** of the Life Cycle Initiative are to provide:

=> Sound methods and data, avoiding arbitrariness in LCA data gathering and modelling.

=> Information in a readily accessible format, together with guidance on its use in different types of applications to facilitate LCA studies.

=> Best available practice and examples representing all regions of the world to stimulate global use of LCA

In this thesis we will examine three main building materials:

- Concrete
- Aggregates

- Steel.

Building waste is a large part of the total solid waste in most urban areas. Significant quantities of construction waste generated daily from construction work of any kind. (Fatta D., A. Papadopoulos, E. Avramikos, E. Sgourou, K. Moustakas, F. Kourmoussis, A. Mentzis and M. Loizidou ,2003)

The waste generated from these activities are materials that do not undergo any significant chemical, physical or biological transformation and for this reason can be considered very friendly to the environment (JC Kaldellis and P. Constantinides ,2003)

The bulk of construction waste consists of concrete, masonry (brick, mortar), asphalt, glass, wood, plastic, steel, aluminum, etc. (Oikonomou N. ,2004) These materials are recyclable and can therefore be taken to a recycling units providing new exploitable structural material.

In EU countries produced about 450 million tons of construction waste per year, while the rate of recycling of these materials reaches 30% In Greece it is estimated that the equivalent annual amount of construction waste amounts to 4 million tons, while the proportion of recycled and reused not exceed 5%. Almost all construction waste in our country refused to uncontrolled areas or available to restore inactive quarries without, however, specific standards (LIFE 00 ENV/GR/000739)

One of the most important developments in our country regarding building waste is the implementation of the 2939 law that sets the legal framework for the collection and use of these materials (Draft Presidential Decree on "Measures and conditions for the alternative management of waste from excavation, construction and demolition waste. Program for the alternative management ",2003) which aims “to reduce the amount of construction waste disposal in uncontrolled environments while increasing the rate of recycling, reuse and other forms of recovery of such materials. It refers that the only responsible managers of construction waste are the producers of the waste, who have the obligation to organize alternative management systems individually or collectively engage in, respectively."

The products of construction waste recycling already used successfully in many countries, in many applications. The most important of these is their use as road material, backfill material in construction projects, material recovery uncontrolled dumps and landfills, drainage material zones in civil engineering and as an aggregate for concrete preparation (Cuperus J.G. and J. Boone ,2003)

C&D waste recycling rates range between below 10% and up to 90%, data collection was possible only for 18 countries.

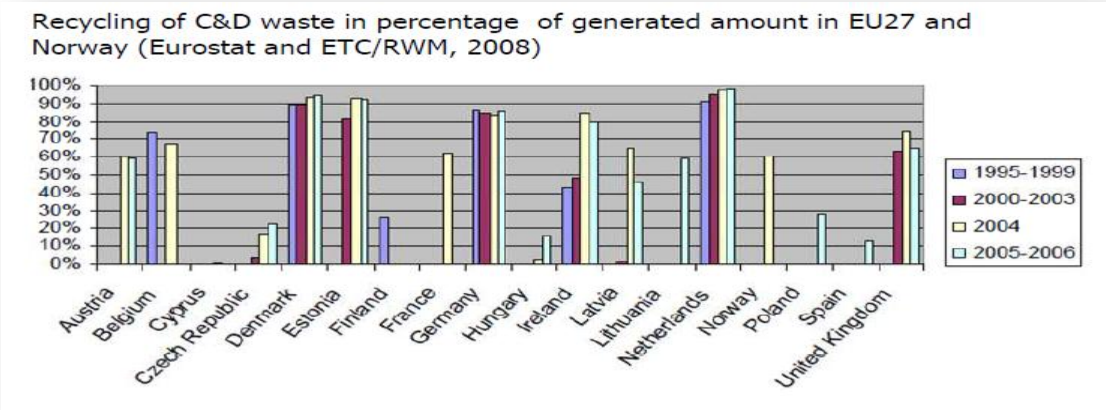


Figure 10.2: Construction and demolition waste in EU

Source: Oikonomou, Mavridou and Georgiadis Filikas

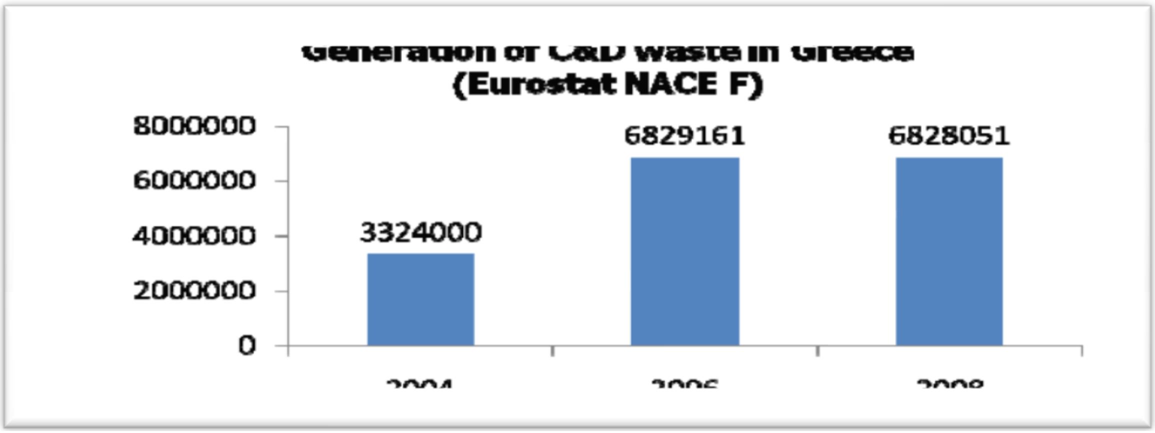


Figure 10.3: Construction and demolition waste (C&D WASTE) in Greece – Governmental decision

Source:. Oikonomou, Mavridou and Georgiadis Filikas

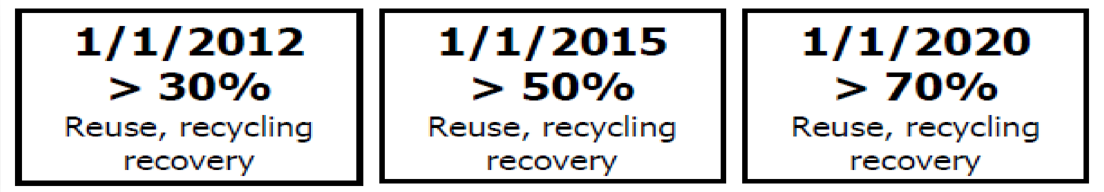


Figure 10.4: Quantitative targets Joint Ministerial Decision 36259/1757/2010

Source:. Oikonomou, Mavridou and Georgiadis Filikas

In 2010 the program for the management of C&D waste was put in place with the Joint Ministerial Decision 36259/1757/E103 (Gov. Gazzete, second issue, 1312/24.8.2010)

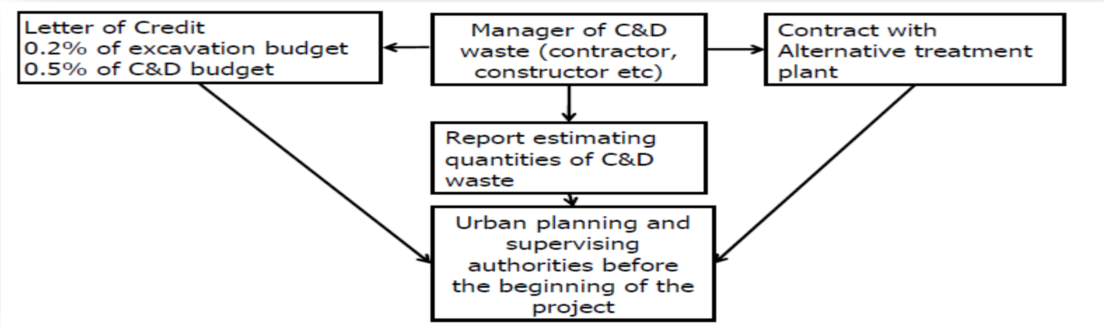


Figure 10.5: Program for management of C&D waste

Source:International Conference on Integrated Urban Solid Waste Management

Greece is in a turning point for C&D waste management because:

- The quantitative targets set by the latest legislative text (2010) require that the recycling rate from the 5% (now) comes up to 30%
- Legislation requires that in every project C&D waste is managed by a treatment plant. This process will be supervised by the urban planning authorities with the guarantee of a letter of credit of 0.2%-0.5% of the total budget of the project.
- It is fortunate that private sector has already established C&D waste treatment plants, so legislation's implementation is expected to be accelerated.

10.3 Concrete

Concrete is the second most consumed material after water and it shapes our built environment. Concrete is an excellent material to make long-lasting and energy-efficient buildings. However, even with good design, human needs change and potential waste will be generated. (www.wbcsdcement.org)

Concrete is made from coarse aggregate (stone and gravel), fine aggregate (sand), cement and water.

- ✓ "Aggregate" consists of large chunks of material in a concrete mix along with finer materials such as sand.
- ✓ "Cement", commonly Portland cement, and other cementitious materials such as fly ash and slag cement.
- ✓ Water is then mixed with this dry composite, which produces a semi-liquid that workers can shape . The water reacts with the cement, which bonds the other components together, creating a robust stone-like material.
- ✓ "Chemical admixtures" are added to achieve varied properties. These ingredients may speed or slow down the rate at which the concrete hardens.
- ✓ "Reinforcements" are often added to concrete. Concrete is usually reinforced with materials that are strong in tension (http://en.wikipedia.org/wiki/Concrete)

C 20/25

A. Cement: Usually: II/42, 5 quantity: 270 kg/m3. Also: II/32, 5 - II/42, 5 or II/32, 5 - II/42, 5

B. Aggregates: Limestone, mostly: 1900 - 1940 kg/m3

C. Water: From network / or boring, usually: 180 - 190 kg/m3

D. Additional: flame normal: 0.2 to 0.4% Net weight of cement. Over / kitchen, usually: 0.4% - 0.8% by weight cement.

Thus producing a concrete with properties:

I) Strength: for C20/25, in 28 days: 29-32 MPa

II) Workability: usually: S3 (10 - 15 false friends) makes it desirable: S4

III) Thickness: usually: 2350 - 2380 kg/m3
IV) Temperature: 10-13oC usually (winter), 28 - 32 ° C (summer)

The use of recycled materials as concrete ingredients has been gaining popularity because of increasingly stringent environmental legislation, and the discovery that such materials often have complimentary and valuable properties. The most conspicuous of these are fly ash, a by-product of coal-fired power plants, and silica fume, a byproduct of industrial electric arc furnaces.

The Cement Sustainability Initiative (CSI) has been looking at the recycling of concrete as a component for sustainable development. Concrete has fairly unique properties and its recovery often falls between standard definitions of reuse and recycling. Concrete is broken down into aggregate and at present, it is used in road sub-base and civil engineering projects.

Construction materials are very significant in our lives, because we spend 90% of our time in buildings or infrastructures (roads, highways, bridges, etc.). The section of construction materials corresponds to 3–4% of the total product in Europe, and the construction industry, as well as construction works, occupy millions of people.(Nik. D. Oikonomou,2005) However, in a parallel manner the construction section is responsible because it:

• takes 50% of raw materials from nature;
• consumes 40% of total energy;
• creates 50% of total waste.

In few countries, full recovery of concrete has been achieved. However, in other countries recovering concrete is overlooked and it ends up in landfill.

Recovering concrete has three main advantages:

(1) Reduces the use of virgin aggregate
(2) Reduces its associated environmental costs of exploitation and transportation
(3) Reduces unnecessary landfill of valuable materials that can be recovered and redeployed.

Recovering concrete, however, has no appreciable impact on reducing greenhouse gas emissions. In the product life cycle of concrete, the main source of carbon emissions is the cement production process (cement is added to aggregates to make concrete).The cement content in concrete cannot be viably separated and reused or recycled into new cement, and thus carbon reductions cannot be achieved by recycling concrete.(The Cement Sustainability Initiative, World Business Council for Sustainable Development)

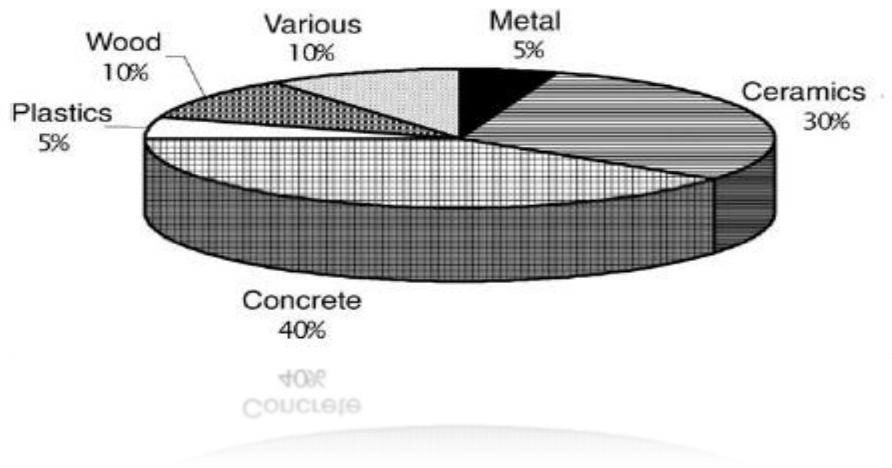


Fig. 10.6: Basic composition of demolition wastes
Source: Oikonomou

Myths	Reality
• Concrete cannot be recycled	Although concrete is not broken down into its constituent parts, it can be recovered and crushed for reuse as aggregate (for use in ready-mix concrete or other applications) or it can be recycled through the cement manufacturing process in controlled amounts, either as an alternative raw material to produce clinker or as an additional component when grinding clinker, gypsum and other additives to cement.
• Recycled concrete aggregate cannot be used for structural concrete	It is generally accepted that about 20% (or more) of aggregate content can be replaced by recycled concrete for structural applications.
• Although some concrete can be recycled it is not possible to achieve high rates	Countries such as the Netherlands and Japan achieve near complete recovery of waste concrete.
• Concrete can be 100% made by recycling old concrete	Current technology means that recovered concrete can be used as aggregate in new concrete but (1) new cement is always needed and (2) in most applications only a portion of recycled aggregate content can be used (regulations often limit content as do physical properties, particularly for structural concrete).
• Recycling concrete will reduce greenhouse gases and the carbon footprint	Most greenhouse gas emissions from concrete production occur during the production of cement. Less-significant savings may be made if transportation needs for aggregates can be reduced by recycling.
• Recycling concrete into low-grade aggregate is down-cycling and is environmentally not the best solution	A full lifecycle assessment should be undertaken. Sometimes low-grade use is the most sustainable solution as it diverts other resources from the project and uses minimal energy in processing. That is not to say more refined uses might not also suit a situation.
• Recycled aggregate is more expensive	This depends on local conditions (including transportation costs).

Figure 10.7: Program for management of C&D waste

Source: World Business Council for Sustainable Development,2012

Truths	Rationale
• Cement cannot be recycled	Once cement clinker is made, the process is irreversible. No commercially viable processes exist to recycle cement.
• Demolition concrete is inert	Compared to other wastes, concrete is relatively inert and does not usually require special treatment.
• Recycled concrete can be better than virgin aggregates for some applications	The physical properties of coarse aggregates made from crushed demolition concrete make it the preferred material for applications such as road base and sub-base. This is because recycled aggregates often have better compaction properties and require less cement for sub-base uses. Furthermore, it is generally cheaper to obtain than virgin material.
• Using recycled aggregate reduces land-use impact	By using recycled aggregates in place of virgin materials (1) less landfill is generated and (2) fewer natural resources are extracted.
• Recycling all construction and demolition waste (C&DW) will not meet market needs for aggregate	Even near complete recovery of concrete from C&DW will only supply about 20% of total aggregate needs in the developed world.
• Figures are not complete for recovery rates	Data are often not available. When data are available different methods of counting make cross-country comparisons difficult.

Figure 10.8: Program for management of C&D waste

Source: The Cement Sustainability Initiative, World Business Council for Sustainable Development,2012

With good initial planning and design of buildings the recovery and reuse of concrete is achievable and will contribute to sustainable buildings and urban societies of the future.

Natural aggregates can be replaced by aggregates made from recycled concrete. Fly ash, slag and silica fume can be used as cementious materials reducing the cement content. These materials can be added as a last step in cement production or when the concrete is made.

Concrete can be recycled from:

• Returned concrete that is fresh (wet) from ready-mix trucks
• Production waste at a pre-cast production facility
• Waste from construction and demolition.

"Most recycled concrete is used as aggregate in road sub-base. When used as a base and sub-base, recycled aggregate has been found to have superior strength to virgin aggregate, providing a very good construction base for new pavement." (World Business Council for Sustainable Development)

Various civil engineering projects can also use coarse aggregate. **When well cleaned, the quality of recycled concrete aggregate is generally comparable to virgin aggregate.** The possibilities for use are equally comparable although the use of crushed concrete in new fresh concrete is rare.

Recycled aggregate accounts for ~6% to 8% of aggregate use in Europe, with significant differences between countries.The greatest users are the United Kingdom, the Netherlands, Belgium, Switzerland and Germany. (World Business Council for Sustainable Development)

Recycled concrete aggregate could even be used for structural concrete. *Australian government guidelines state that up to 30% of recycled aggregate can be used for* *structural concrete without any noticeable difference in workability and strength compared with virgin aggregate.*

Issue	Barriers	Benefits
Material cost vis-à-vis natural aggregate	Low economic cost of virgin aggregate in some countries.	Aggregates levies and transportation costs for natural aggregates can be higher. Overall project costs can be reduced as less landfill taxes/fees are paid on C&DW as the material is recovered instead of being landfilled.
Availability of material	Non-regular supply of C&DW.	C&DW is usually found in urban areas near construction and development projects. Virgin materials often need to be transported over greater distances.
Processing infrastructure	C&DW on-site waste management plans are needed. C&DW may need to be sorted. High-value recovered concrete requires costly processes.	Once infrastructure is established mobile sorting units and dedicated facilities can provide good returns.
Public attitudes	Misconception that recovered concrete is of lower quality. New materials are perceived as being of better quality.	Increasing environmental concerns leading to increased demand for eco-friendly products and reuse of materials.
Laws, regulations and industry accepted standards	Classification of recovered concrete as waste can increase reporting and permit requirements. Extra limitations can be placed on use.	Positive recycling laws, landfill taxes and green procurement policies by large users can all promote recycled concrete use.
Environmental impacts	Processing technology for recovery of concrete should consider possible air and noise pollution impacts as well as energy consumption, although there is little difference to natural aggregates processing.	Within a life cycle analysis, use of recovered concrete can lower overall environmental impact. • Failing to use recovered materials increases landfill and associated environmental and health costs • Failing to use recovered materials means virgin materials are used instead • Recovered concrete is generally inert • In some cases, transportation needs for recycled concrete can be lower than virgin materials (often not located in urban development areas) and as such fuel consumption, CO_2 emissions and road and vehicle use can be reduced.
Physical properties	For specialized applications (e.g. high performance concrete) there are some limitations on fitness for use. Technology can also limit recycling options.	For most uses, recycled concrete performs well.

Figure 10.9: Program for management of C&D waste

Source: World Business Council for Sustainable Development,2012

Concrete can be and is being recovered. The Cement Sustainability Initiative (CSI) supports initiatives targeted at an ultimate goal of "zero landfill" of concrete.

Towards the "zero landfill" of concrete goal, the following recommendations are made (www.wbcsdcement.org):

• Key stakeholder dialogue to develop reliable and consistent statistics

• Governments and other key players to publicize construction and demolition waste data

• Set targets for use in both road construction and building industries

• Develop economic incentives and legislation to allow infrastructure to develop and to promote concrete recycling

• Research and development to consider further recovery techniques and uses

• Green building schemes should further encourage good construction and demolition waste management and the use of recycled concrete aggregate

• Key stakeholder publicity to change public misconceptions

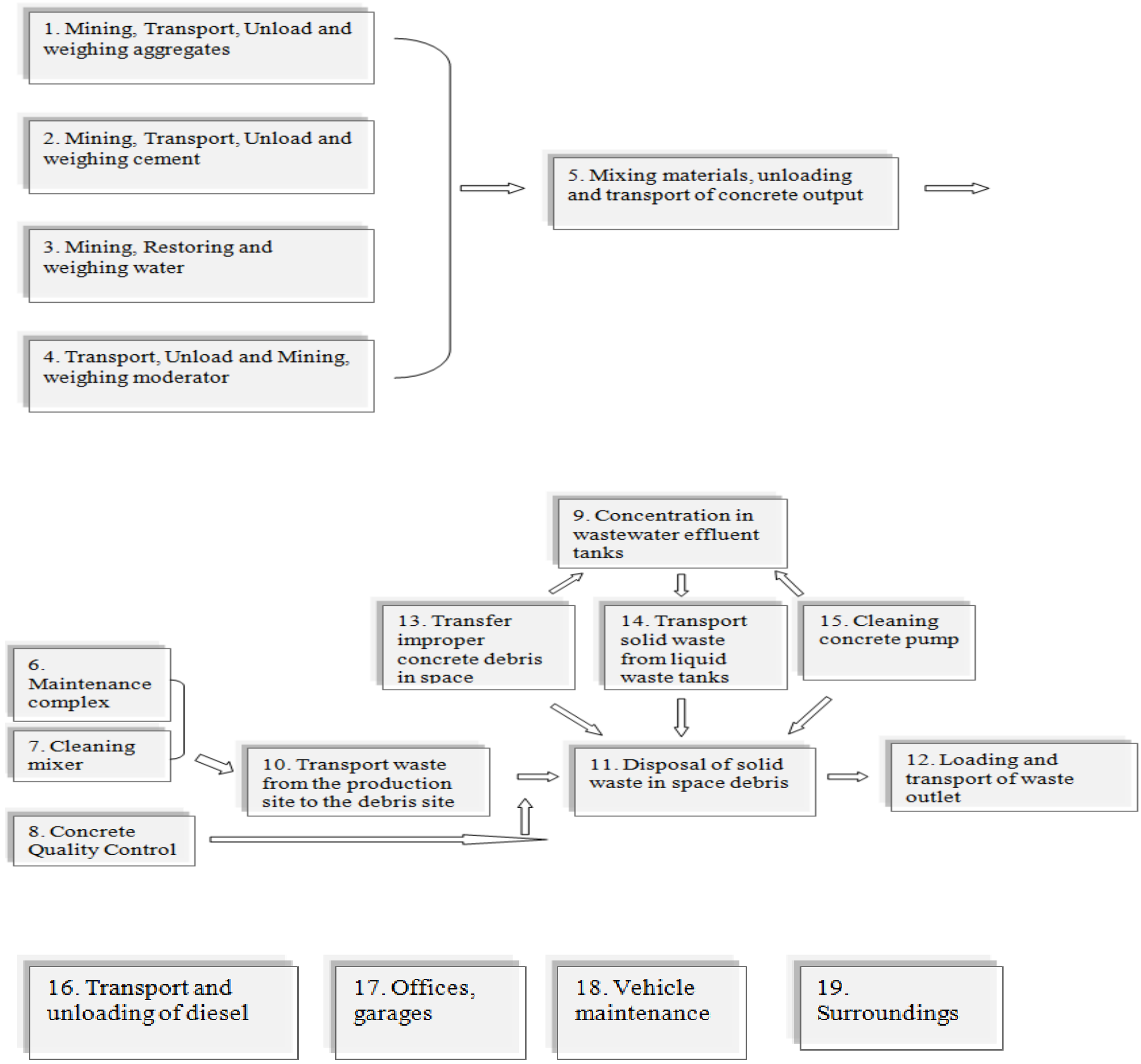


Figure 10.10:Flowchart of production of ready mixed concrete

Source:Biska and Oikonomou ,2006

Table 10.1: Inputs and outputs for 1m³ concrete C20/25 in all sections

	1 m3 concrete C20/25					
INPUTS	1	2	3	4	5	6
Gravel	0	0	0	0	249,9678	0
Sand	0	0	0	0	1089,9756	0
Cement	0	0	0	0	310	0
retarder	0	0	0	0	0,75	0
water drilling	0	0	0	0	200,3	10
water supply	0	0	0	0	0	0
OILS	0	0	0	0	0	0,0013
Greases	0	0	0	0	0	0,0008
Diesel	0,2263	0,048	0	0,0005	0,1361	0
electricity	0,6978	0,3852	0,3225	0,0103	0,9847	0,0802
OUTPUTS						
CO	1,8596	0,3958	0	0,0045	1,2069	0
Nox	4,5754	1,323	0	0,0203	4,1073	0
VOC	1,4709	0,3164	0	0,0036	0,9451	0
PM	0,4608	0,1123	0	0,0013	0,3406	0
S.W (wastage)	0,0959	0	0	0	0,6369	0,25
S.W(barrel)	0	0	0	0	0	0,00017
S.W(container)	0	0	0	0	0	0,00005
Liquid (surface)	0	0	0	0	0,3592	10,0232
Liquid (separation)	0	0	0	0	0	0
Liquid (mining)	0	0	0	0	0	0

7	8	9	10	11	12	13	14
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
3,75	0	0	0	0	0	105	15
0	5	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0,0006	0	0,0008	0,0197	0,002
0,0048	0,0439	0	0	0	0	0,0498	0,0136
0	0	0	0,0054	0	0,0075	0,2154	0,0331
0	0	0	0,0122	0	0,0225	0,7124	0,1112
0	0	0	0,004	0	0,0057	0,1464	0,021
0	0	0	0,0013	0	0,002	0,0582	0,0092
1	1,3499	0	0	21,407	0	0,549	0,183
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
3,8429	0	0	0	0	0	105,051	15,017
0	5	0	0	0	0	0	0
0	0,1255	0	0	1,8799	0	0	0

15	**16**	**17**	**18**	**19**		
0	0	0	0	0	249,9678	Kg
0	0	0	0	0	1089,9756	Kg
0	0	0	0	0	310	Kg
0	0	0	0	0	0,75	Kg
0	0	0	0	50,54	384,59	Kg
0	0	1,25	0	0	6,25	Kg
0	0	0	0,08	0	0,0813	Kg
0	0	0	0,0026	0	0,0034	Kg
0	0,0024	0	0	0	0,4364	Kg
0	0	0	0,1582	0,1488	2,8998	Kwh
0,0009	0,0244	0	0	0	3,7535	Kg
0,0025	0,1081	0	0	0	10,9949	Kg
0,0008	0,0196	0	0	0	2,9335	Kg
0,0001	0,0071	0	0	0	0,9929	Kg
0	0	0	0	0	25,4717	Kg
0	0	0	0,00765	0	0,00782	Kg
0	0	0	0,00016	0	0,00021	Kg
0	0	0	0	0	134,2933	Kg
0	0	1,25	0	0	6,25	Kg
0	0	0	0	50,54	52,5454	Kg

Source:Biska and Oikonomou ,2006

Table 10.2: Consumptions and emissions for 1m³ concrete C20/25

INPUTS	1 m3 concrete C20/25	
Gravel	509,9608	Kg
Chippings	249,9678	Kg
Sand	1089,9756	Kg
Cement	310	Kg
Retarder	0,75	Kg
Water drilling	384,59	Kg
Water supply	6,25	Kg
OILS	0,0813	Kg
Greases	0,0034	Kg
Diesel	0,4364	Kg
Electricity	2,9	Kwh
OUTPUTS		
CO	0,0038	Kg
Nox	0,011	Kg
VOC	0,0029	Kg
PM	0,001	Kg
Solid waste	25,4707	Kg
CL	0,00267	Kg
SO4	0,04297	Kg
Ca	0,01719	Kg
Mg	0,01588	Kg
NO3	0,0022	Kg
NO2	0,00005	Kg
NH4+	0,00004	Kg
Fe	0,00001	Kg
Mn	0,00001	Kg
PO4	0,00001	Kg
Liquid waste	1,978	Kg
Solid waste	0,4682	Kg
CO2	3,828	Kg
SO2	0,0034	Kg
NOx	0,0029	Kg
PM	0,0007	Kg

Source:Biska and Oikonomou ,2006

Table 10.3: Main substances emitted to air

Table 1b
Summary of the main substances emitted to air (in kg) on the cement plant for the production of 1 kg of cement CEM I.

Air emissions (kg/kg cement)	This study[a]		ATILH[b]
	Mean	Std	
Chlorine (Cl)	2.9×10^{-6}	5.2×10^{-6}	
Hydrochloric acid (HCl)	8.8×10^{-6}	3.5×10^{-6}	4.0×10^{-6}
Fluorine and inorganic compounds	1.5×10^{-7}	5.7×10^{-8}	1.0×10^{-6}
Benzene (C_6H_6)	3.3×10^{-6}	1.1×10^{-8}	
Carbon monoxide (CO)			1.4×10^{-3}
Methane (CH_4)			2.0×10^{-5}
Non-methane volatile organic compounds (NMVOC)	4.5×10^{-5}	2.7×10^{-5}	5.0×10^{-5}
Carbon dioxide (CO_2)	6.9×10^{-1}	1.4×10^{-1}	8.1×10^{-1}
Mercury and derivates (Hg)	3.4×10^{-8}	2.2×10^{-8}	1.2×10^{-8}
Nitrogen oxides (NO_X) (eq. NO_2)	1.2×10^{-3}	3.2×10^{-4}	1.5×10^{-3}
Sulphur oxides (SO_X) (eq. SO_2)	8.2×10^{-4}	4.7×10^{-4}	5.8×10^{-4}
Nitrous oxide (N_2O)	9.7×10^{-6}	1.7×10^{-5}	
Ammonia (NH_3)	7.2×10^{-4}	5.1×10^{-4}	4.7×10^{-5}
Particulates	4.9×10^{-4}		4.0×10^{-5}
Copper and derivates (Cu)	2.8×10^{-7}	1.7×10^{-9}	3.9×10^{-8}
Manganese and derivates (Mn)	2.8×10^{-7}	8.8×10^{-8}	4.6×10^{-8}
Nickel and derivates (Ni)	1.6×10^{-7}	9.7×10^{-8}	8.3×10^{-8}
Zinc and derivates (Zn)	9.8×10^{-7}	7.5×10^{-7}	1.6×10^{-8}
Antimony (Sb)	1.8×10^{-9}	1.3×10^{-9}	3.9×10^{-8}
Tin (Sn)	7.3×10^{-9}	3.2×10^{-9}	1.7×10^{-8}
Cobalt (Co)	1.4×10^{-8}		1.4×10^{-8}
cadnium (Cd)	2.6×10^{-8}	1.1×10^{-8}	1.4×10^{-8}
Arsenic (As)	3.2×10^{-8}		8.0×10^{-9}
Chromium (Cr)	6.4×10^{-8}		2.4×10^{-8}
Lead (Pb)	2.2×10^{-7}	$1.3 \times 10-7$	1.1×10^{-7}
Titanium (Ti)			4.0×10^{-8}
Vanadium (V)			4.6×10^{-8}
Selenium (Se)			1.3×10^{-8}
Tellurium (Te)			1.1×10^{-8}

[a] Data for *This study* are from (EPER, 2008; Holcim, 2009; Calcia, 2008; Barla, 2008; Braun, 2007; DRIRE, 2003; AEPI, 2001; Lafarge, 2009).
[b] Data for *ATILH* are from (ATILH, 2002).

Source: Chena, Habert , Bouzidi ,Jullienc

According to the two above table we will carry out the Lca for the cement

10.4 Aggregates

Construction aggregate, or simply "*aggregate*", is a broad category of coarse particulate material used in construction. They include sand, gravel,crushed stone, slag, recycled concrete and geosynthetic aggregates.Aggregates are a component of composite materials such as concrete and asphalt concrete.

Due to the relatively high hydraulic conductivity value, aggregates are widely used in drainage applications such as foundation and French drains, septic drain fields, retaining wall drains, and road side edge drains.Aggregates are also used as base material under foundations, roads, and railroads. (http://en.wikipedia.org/wiki/Construction_aggregate)

We will refer aggregates in this thesis that are extracted and processed from primary resources through to the point of their dispatch as aggregates and compare them also with the processing of equivalent recycled aggregates to ascertain and quantify all the environmental impacts of each phase in the product life cycle.

Except from crushing and screening, the aggregates processing component of the work also includes the Life Cycle impacts of excess production of fines, washing of recycled aggregates to enable further processing of fines and other aggregate sizes and the disposal options for inert construction and demolition wastes.(Life Cycle Assessment of Aggregates, EVA025 , 2009)

10.4.1 Demand for aggregates

Aggregates are the most commonly used construction minerals. In the UK, Craighill and Powell (1999) applied an LCA approach to evaluate the environmental, social and economic impacts of alternative methods of managing construction and demolition waste. *They concluded that the reuse of such waste on site performed better than off site recycling, which in turn performed better than landfill disposal.*

10.4.2 LCA of Aggregeates

The aggregates extraction subsystem developed includes overburden stripping, drilling and blasting, and restoration of the site, while the processing subsystem includes washing, classifying, crushing and screening of primary aggregates as well as the processing of equivalent recycled aggregates (conventional screening and crushing and washing processes that enable the further processing of fines and other aggregate sizes).

The LCA will include all resource inputs (materials, energy etc.), all waste (e.g. overburden waste, fines etc.) and emission streams (e.g. all gaseous emissions including

CO_2, Particulate Matter etc.) and will quantify the relevant environmental impacts at each phase in the product life cycle.

The LCA system will provide the facility to consider the relative proximity of sources of primary aggregates and recycled aggregates to the market place as well as disposal options for inert construction and demolition wastes.

The primary aggregates system comprises three life cycle phases:

Extraction

"The extraction phase includes ***three sub-phases**, namely overburden removal, primary fragmentation, loading and hauling.* These operations are considered to include all the necessary elements representative of the primary aggregates extraction processes " (Smith, 2001).

Processing

The Processing life cycle phase is composed of ***five sub-phases** for the hard rock primary aggregates: primary crushing, scalping screening, secondary crushing, tertiary crushing, quaternary crushing and final screening.*

"The specific processing operations vary greatly as they are influenced by a large number of parameters, such as the aggregate properties, potential waste products, operating criteria, methods of stockpiling, storage and shipping, space availability and safety" (Barksdale, 1996).

Waste Management/Restoration.

Restoration in most sand and gravel operations is progressive. On the other hand, restoration of crushed rock quarries is often carried out after a major production phase is completed. The soil/overburden is usually replaced in the disturbed areas of the operation surrounding the quarry to help restoring vegetation, making these areas ready for a previously agreed purpose. This may be for landfilling, agriculture, wildlife or as a new public amenity

10.4.3 Key assumptions and limitations

1. This study does not cover the impact categories addressing the issues of land use, waste generated or resource use.
2. The amount of fuel/electricity per declared unit (1 tonne of aggregate) is also calculated.

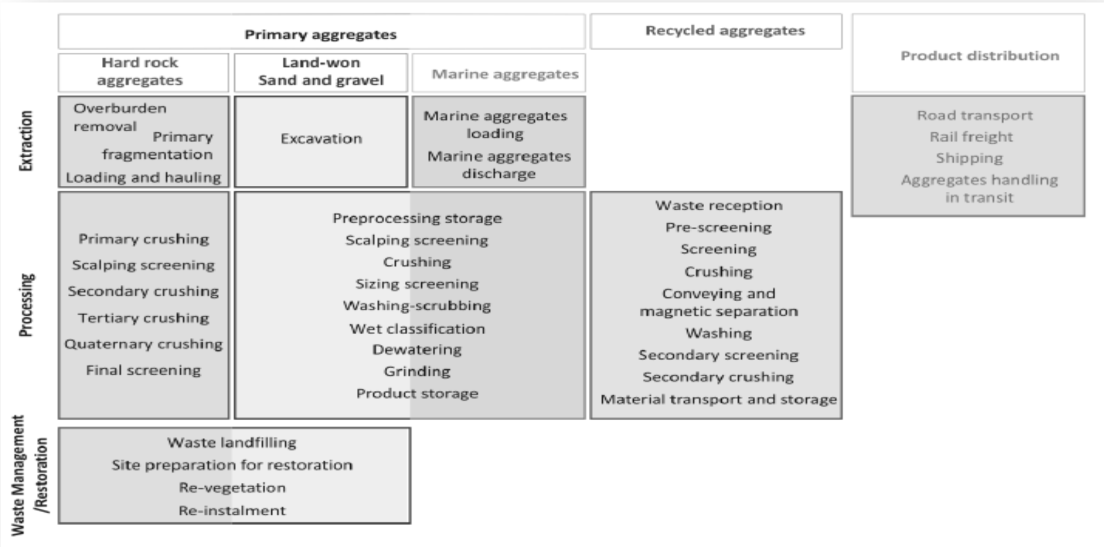


Figure 10.11: Aggregates LCA system, individual phases and corresponding unit processes.

Source: Korre A.and Durucan S.,2009

Table 10.5: Atmospheric emissions estimated by the aggregates tools

	Crushed rock tool	Land-won sand and gravel tool	Marine sand and gravel tool	Recycled Aggregates tool	Product distribution tool
Combustion gases:					
CO	✓	✓	✓	✓	✓
Benzene	✓	✓	✓	✓	✓
1,3-Butadiene	✓	✓	✓	✓	✓
CO_2	✓	✓	✓	✓	✓
NO_x	✓	✓	✓	✓	✓
PM_{10}	✓	✓	✓	✓	✓
CH_4	✓	✓	✓	✓	✓
N_2O	✓	✓	✓	✓	✓
NMVOC	✓	✓	✓	✓	✓
SO_2			✓		
Mercury			✓		
Lead			✓		
Benzo(a)pyrene			✓		
Blasting fumes:					
CO_2	✓				
CO	✓				
NO_2	✓				
NH_3	✓				
Dust:					
TSP	✓	✓	✓		✓
PM10	✓	✓	✓	✓	✓

Source: Korre A.and Durucan S.,2009

Table 10.6: Crushed rock aggregates system example: Impact assessment results per unit process per one tonne of aggregate produced

Impact Category Units	**Unit process** Primary fragmentation	Loading & hauling	Primary crushing	Scalping screening	Secondary crushing	Tertiary crushing	Quaternary crushing	Final screening	Backfill	**Total impact**
Global Warming kg CO_2 eq	$4.47X10^{-2}$-$1.11X10^{-1}$	$7.83X10^{-2}$-$1.94X10^{-1}$	$2.66X10^{-1}$-$9.52X10^{-1}$	$5.68X10^{-3}$-$1.63X10^{-1}$	$7.94X10^{-2}$-$7.50X10^{-1}$	$1.86X10^{-2}$-$5.31X10^{-1}$	$3.99X10^{-1}$	$1.38X10^{-1}$-$1.87X10^{-1}$	$1.05X10^{-2}$	1.48- 2.52
Eutrophication kg PO_4 eq	$1.35X10^{-4}$-$1.38X10^{-4}$	$4.21X10^{-5}$-$9.31X10^{-5}$	$7.14X10^{-5}$-$2.55X10^{-4}$	$2.77X10^{-6}$-$7.97X10^{-5}$	$2.13X10^{-5}$-$2.01X10^{-4}$	$4.98X10^{-6}$-$1.42X10^{-4}$	$1.07X10^{-4}$	$4.02X10^{-5}$-$7.25X10^{-5}$	$3.83X10^{-7}$	$5.51X10^{-4}$-$8.78X10^{-4}$
Acidification kg SO_2 eq	$5.45X10^{-4}$-$8.87X10^{-4}$	$4.90X10^{-4}$-$1.22X10^{-3}$	$1.47X10^{-3}$-$5.24X10^{-3}$	$4.93X10^{-5}$-$1.42X10^{-3}$	$4.37X10^{-4}$-$4.13X10^{-3}$	$1.02X10^{-4}$-$2.92X10^{-3}$	$2.20X10^{-3}$	$7.60X10^{-4}$-$1.06X10^{-3}$	$5.49X10^{-6}$	$8.58X10^{-3}$-$1.48X10^{-2}$
Photo-oxidant formation kg ethylene eq	$2.70X10^{-5}$-$9.07X10^{-5}$	$6.71X10^{-5}$-$1.73X10^{-4}$	$8.40X10^{-5}$-$3.00X10^{-4}$	$4.41X10^{-6}$-$1.27X10^{-5}$	$2.50X10^{-5}$-$2.37X10^{-4}$	$5.87X10^{-6}$-$1.67X10^{-4}$	$1.26X10^{-4}$	$4.34X10^{-5}$-$7.57X10^{-5}$	$8.15X10^{-5}$	$6.78X10^{-4}$-$9.94X10^{-4}$
Human toxicity kg 1,4-DB eq	$1.00X10^{-1}$-$1.72X10^{-1}$	$5.79X10^{-2}$-$6.18X10^{-02}$	$3.97X10^{-2}$-$8.59X10^{-2}$	$2.13X10^{-2}$-$2.71X10^{-2}$	$5.92X10^{-3}$-$5.59X10^{-2}$	$4.71X10^{-3}$ - $7.46X10^{-2}$	$2.77X10^{-2}$	$1.30X10^{-2}$-$3.77X10^{-2}$	$1.15X10^{-3}$	$3.37X10^{-1}$-$4.08X10^{-1}$
Freshwater Aquatic Ecotoxicity kg 1,4-DB eq.	$1.97X10^{-5}$-$1.62X10^{-3}$	$1.47X10^{-3}$-$3.87X10^{-3}$	$3.99X10^{-4}$-$1.43X10^{-3}$	$6.76X10^{-5}$-$1.94X10^{-3}$	$1.19X10^{-4}$-$1.12X10^{-3}$	$2.78X10^{-5}$-$7.94X10^{-4}$	$5.98X10^{-4}$	$2.03X10^{-4}$-$8.07X10^{-4}$	$1.81X10^{-5}$	$5.98X10^{-3}$-$9.00X10^{-3}$
Marine Aquatic Ecotoxicity kg 1,4-DB eq.	$3.07X10^{-1}$-25.27	22.97-60.27	13.01-46.42	$1.20x10^{-3}$-34.45	3.88-36.63	$9.08x10^{-1}$-25.90	19.51	6.61-16.27	$2.82 X10^{-1}$	124.74-198.40
Terrestrial Ecotoxicity kg 1,4-DB eq.	$8.69X10^{-6}$-$7.16X10^{-4}$	$6.51X10^{-4}$-$1.71X10^{-3}$	$1.91X10^{-4}$-$6.82X10^{-4}$	$3.02X10^{-5}$-$8.67X10^{-4}$	$5.69X10^{-5}$-$5.37X10^{-4}$	$1.33X10^{-5}$-$3.80X10^{-4}$	$2.86X10^{-4}$	$9.69X10^{-5}$-$3.64X10^{-4}$	$7.98X10^{-6}$	$2.71X10^{-3}$-$4.10X10^{-3}$
Ozone layer depletion kg R11 eq.	$1.65X10^{-11}$-$1.36X10^{-9}$	$1.23X10^{-9}$-$3.23X10^{-9}$	$3.90X10^{-8}$-$1.39X10^{-7}$	$8.82X10^{-10}$-$2.54X10^{-8}$	$1.16X10^{-8}$-$1.10X10^{-7}$	$2.73X10^{-9}$-$7.77X10^{-8}$	$5.86X10^{-8}$	$1.98X10^{-8}$-$2.39X10^{-8}$	$1.51X10^{-11}$	$1.85X10^{-7}$-$3.39X10^{-7}$

Source: Korre A.and Durucan S.,2009

Table 10.7: Crushed rock aggregates system example: Range of impact assessment results for different crushed rock aggregate products per one tonne of aggregate produced.

Impact Category Units	**Product category A** Subbase, capping layers, crusher runs, agricultural lime, scalping, 80-40 mm, 150 mm, 125 mm, 40 mm, dust 6mm, dust 3mm	**Product category B** 28 mm, 20 mm, 14 mm, 10 mm
Global Warming kg CO_2 eq	0.51-1.35	2.43-4.14
Eutrophication kg PO_4 eq	$3.05X10^{-4}$-$5.65X10^{-4}$	$8.24X10^{-4}$-$1.31X10^{-3}$
Acidification kg SO_2 eq	$3.28X10^{-3}$-$8.41X10^{-3}$	$1.39X10^{-2}$-$2.38X10^{-2}$
Photo-oxidant formation kg ethylene eq	$2.89X10^{-4}$-$6.27X10^{-4}$	$8.95X10^{-4}$-$1.51X10^{-3}$
Human toxicity kg 1,4-DB eq	0.22-0.35	0.44-0.63
Freshwater Aquatic Ecotoxicity kg 1,4-DB eq.	$4.35X10^{-3}$-$7.26X10^{-3}$	$7.23X10^{-3}$-$1.14X10^{-2}$
Marine Aquatic Ecotoxicity kg 1,4-DB eq.	74.79-141.46	$1.81x10^{3}$-$3.20x10^{3}$
Terrestrial Ecotoxicity kg 1,4-DB eq.	$1.94X10^{-3}$-$3.26X10^{-3}$	$3.31X10^{-3}$-$5.26X10^{-3}$
Ozone layer depletion kg R11 eq.	$4.32X10^{-8}$-$1.68X10^{-7}$	$3.24X10^{-7}$-$5.76X10^{-7}$

Source: Korre A.and Durucan S.,2009

10.5 Recycled aggregates

The information reported in Table 10.6 present the impact assessment results calculated for the production of one tonne of recycled aggregate material at an example recycling site.

The product distribution tool was used to calculate the impacts relating to material transport to the recycling site. For the particular case reported here, the distance of source to recycling site was set at 353 km and it was assumed that the material is transported using 32 tonne trucks consuming diesel at 0.46 MJ/tonne.km.

Table 10.8 Recycled aggregates system example: Impact assessment results per unit process per one tonne of recycled aggregate produced

Impact Category Units	Unit process						
	Waste reception	Crushing	Conveying & Magnetic separation	Washing	Secondary Crushing	Material transport & Storage	Total Impact
Global Warming kg CO_2 eq		0.2304	$7.72x10^{-3}$	1.92	0.0659	0.1957	2.42
Eutrophication kg PO_4 eq		$7.22x10^{-5}$	$1.6x10^{-6}$	$5.25x10^{-04}$	$1.37x10^{-05}$	$9.27x10^{-05}$	$7.06x10^{-04}$
Acidification kg SO_2 eq		$2.78x10^{-4}$	$6.16x10^{-6}$	$10.56x10^{-3}$	$5.26x10^{-5}$	$1.22x10^{-3}$	$12.13x10^{-3}$
Photo-oxidant formation kg ethylene eq		$1.70x10^{-5}$	$4.12x10^{-7}$	$6.05\ x10^{-4}$	$3.52x10^{-6}$	$1.74x10^{-4}$	$8.00x10^{-4}$
Human toxicity kg 1,4-DB eq	$1.08x10^{-05}$	0.0943	$4.39x10^{-4}$	0.1389	0.0214	$22.37x10^{-3}$	0.1733
Freshwater Aquatic Ecotoxicity kg 1,4-DB eq.		$6.19x10^{-12}$	$4.65x10^{-18}$	$28.59\ x10^{-4}$	$3.97x10^{-17}$	$19.55x10^{-4}$	$19.55\ x10^{-4}$
Marine Aquatic Ecotoxicity kg 1,4-DB eq		$1.83x10^{-10}$	$2.59x10^{-17}$	93.23	$2.21x10^{-16}$	30.45	30.45
Terrestrial Ecotoxicity kg 1,4-DB eq		$1.04x10^{-12}$	$4.40x10^{-19}$	$13.68x10^{-4}$	$3.76x10^{-18}$	$8.62x10^{-4}$	$8.62x10^{-4}$
Ozone layer depletion kg R11 eq.				$2.80x10^{-7}$		$3.27x10^{-9}$	$2.83x10^{-7}$

Source: Korre A.and Durucan S.,2009

10.6 LCA of steel (Kaplan turbin)

Selecting the most appropriate materials for any application depends on the consideration of a range of technical and economic factors such as functionality, durability and cost. A further and increasingly important factor for material specifiers is the associated environmental performance.

Among the tools available to evaluate environmental performance, life cycle assessment (LCA) provides a holistic approach to evaluate environmental performance and it considers the potential impacts from a cradle-to-grave approach**.** (Methodology report Life cycle inventory study for steel products).

In addition, cradle-to-gate inventories do not include: R&D, business travel, production and decommissioning, repair and maintenance, cleaning and legal services, marketing, operation of administration offices, etc

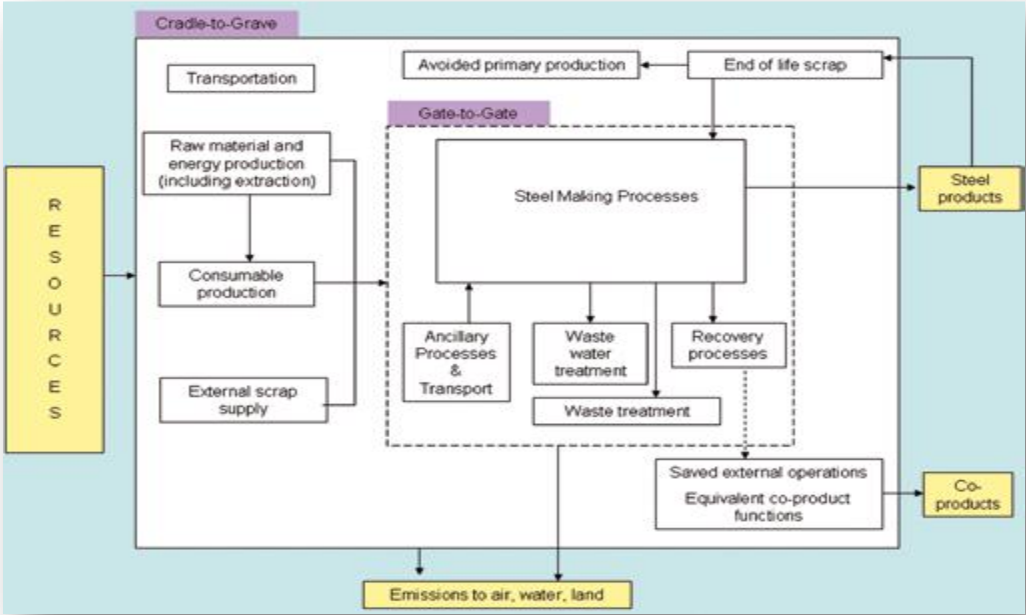


Figure 10.12: System overview, with end-of-life recycling
Source: World Steel Association,2011

As shown in Figure 10.12, the system boundaries for the LCI for steel products encompass the activities of the steel manufacturing sites and the production and transport of raw material inputs, energy sources and other consumables (diesel for internal transport, oxygen, nitrogen, etc.).

The list in the below Table 10.9 includes the significant emissions for global warming, air acidification and eutrophication indices, a number of metals, and some additional emissions to water.

Table 10.9: List of accounted air and water emissions

Accounted emission		Flows
Air	Greenhouse gases	CO_2, CH_4, N_2O
	Acidification gases	NO_X, SO_X as SO_2, HCl, H_2S
	Organic emissions	Dioxins VOCs (excluding methane)
	Metals	Cd, Cr, Pb, Zn
	Others	CO, Particulates (Total)
Water	Metals	Cr, Fe, Zn, Pb, Ni, Cd
	Others	N (except ammonia), P compounds, Ammonia, COD, Suspended matter

Source: World Steel Association,2011

Steel which was recovered within the site was specified as an output from the process in which it was produced and as an input for the process where it was then re-used. The materials exported from the site for external applications have been classified as co - products (or waste for recovery).

Significant material co-products are assumed to replace functionally similar products or can be used in cement manufacture ,for road construction or aggregate, or as a fertiliser. Approximately 95% of the total amount of steel produced is recovered and over 80% is used for cement making.

The environmental benefits of saving cement is much higher, in terms of energy resources and air emissions at least, than those associated to aggregates.

Table 10.10: Steelmaking co-products

Production process	Main co-products	Allocation method
Coke oven	CO gas	System expansion
	Coke Benzene Tar Toluene Xylene Sulphur	System expansion
Blast furnace	Blast furnace gas Hot metal Slag	System expansion
Basic oxygen furnace (BOF)	BOF gas Crude steel Slag	System expansion
EAF	Crude steel Slag	System expansion

Source: World Steel Association,2011

Steel is completely recyclable. Therefore, it is important to consider recycling in LCA studies involving steel. There is a growing market for steel products and there are no changes to the inherent properties of the steel when it is recycled and steel can be recycled over and over again.

Due to the maturity of the steel recycling system that has developed across the world, steelmakers and scrap merchants have harmonised the use of the steel scrap for relevant products to minimise the costs in treatment of scrap for use in the new steel products.Some products are recycled into lower quality products, in the same way that some scrap steel is recycled into higher quality products such as aerospace steels.

Typical rates for the automotive sector are above 95%, for construction around 85% and for packaging around 70%.

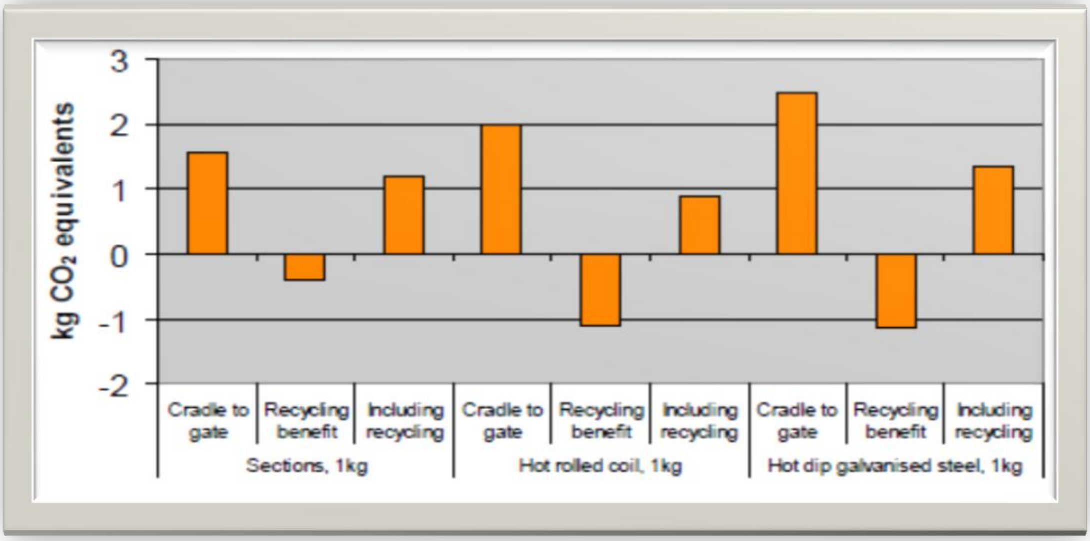


Figure 10.13: Global warming potential (CO2e) of steel products

Source: World Steel Association,2011

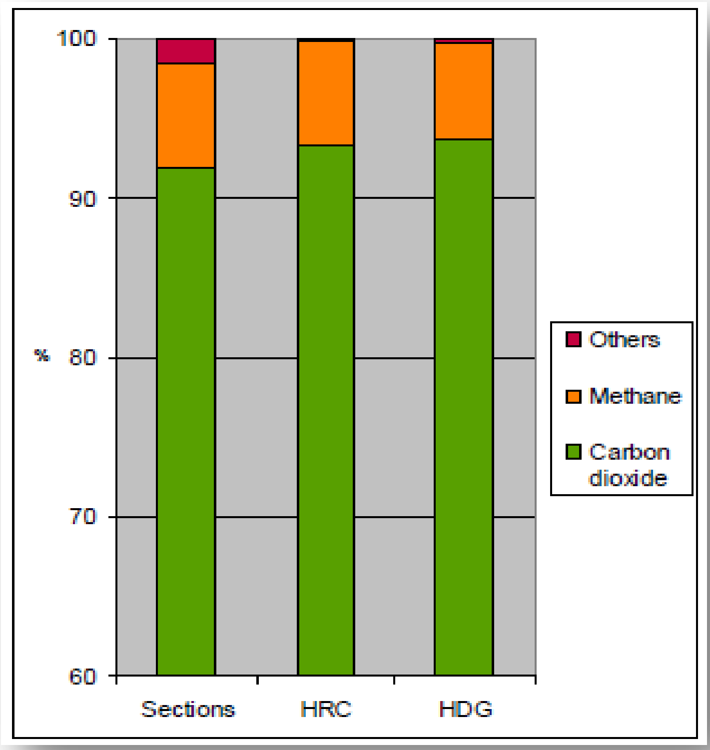


Figure 10.14: Contributions to global warming potential of steel products

Source: World Steel Association,2011

Table10.11: Life cycle impact assessment results of steel products

		PED MJ	GWP kg CO_2e	AP kg SO_2e	EP kg phosphate e	POCP kg ethene e
Sections, 1 kg	Cradle-to-gate	19.6	1.6	0.0045	0.00036	0.0008
	Including recycling	16.4	1.2	0.0037	0.00034	0.0006
	Recycling benefit	-3.2	-0.4	-0.0008	-0.00002	-0.0002
Hot-rolled coil, 1 kg	Cradle-to-gate	21.6	2.0	0.0052	0.00035	0.00094
	Including recycling	11.9	0.9	0.0025	0.000282	0.00035
	Recycling benefit	-9.7	-1.1	-0.0027	-6.8E-05	-0.00059
Hot-dip galvanized steel, 1 kg	Cradle-to-gate	27.5	2.5	0.0074	0.00048	0.0012
	Including recycling	17.5	1.3	0.0047	0.00041	0.00061
	Recycling benefit	-10.0	-1.2	-0.0027	-0.00007	-0.00059

Source: World Steel Association,2011

Hot-rolled coil is generally further processed into finished products by the manufacturers and can be used in transport, construction, ship-building, pressure vessels, pipelines, etc. We will use this in our study.

This steel is made up of both renewable and non-renewable resources. For the cradle-to gate data for each of the three products shown above, more than 97% of the demand is from non-renewable resources, with the majority being attributable to hard coal consumption, see Figure 10.15 below.

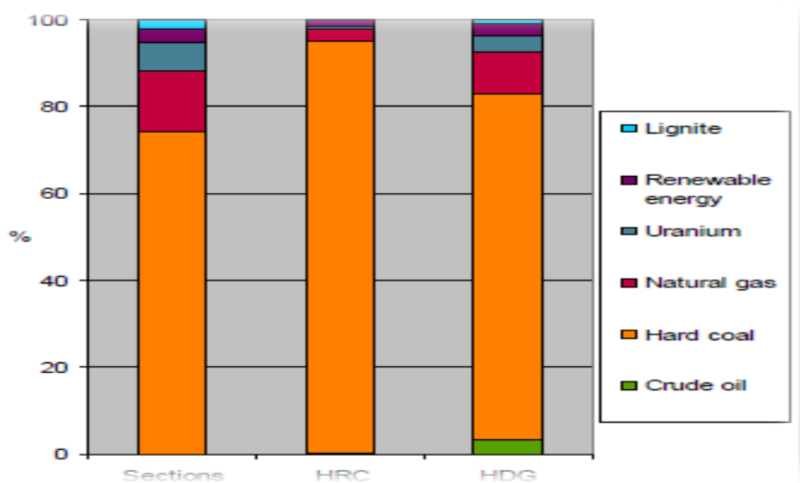


Figure 10.15: Contributions to primary energy demand of steel products

Source: World Steel Association,2011

Table 10.12: Sensitivity analysis of system expansion

		PED MJ	GWP kg CO_2e
Sections, 1 kg	Excluding system expansion	21.75	1.65
	Including system expansion	19.64	1.56
	% Difference	-9.7%	-5.7%
Hot-rolled coil, 1 kg	Excluding system expansion	25.96	1.83
	Including system expansion	21.64	2.01
	% Difference	-16.6%	9.8%
Hot-dip galvanized steel, 1 kg	Excluding system expansion	31.61	2.35
	Including system expansion	27.59	2.47
	% Difference	-12.7%	5.1%

Source: World Steel Association,2011

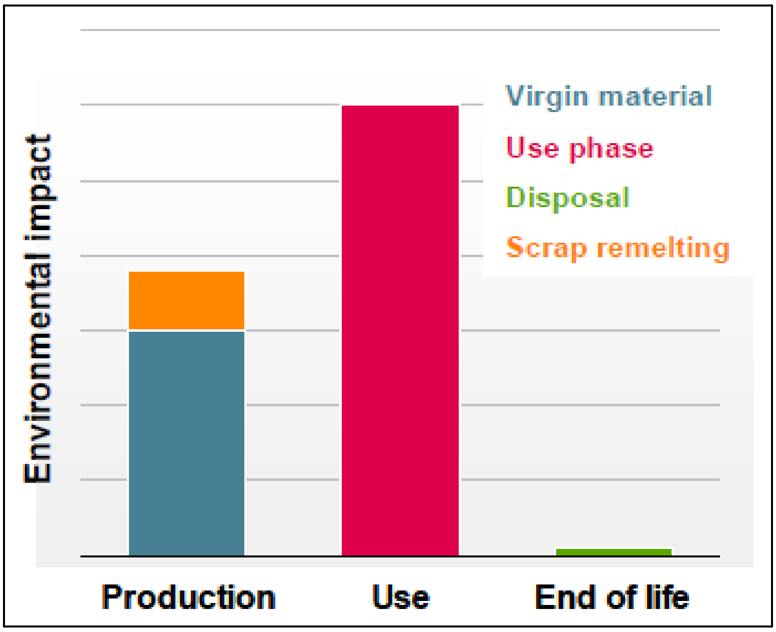


Figure 10.16: Cut-off approach for a product system that uses both primary and recycled steel inputs

Source: European Reference Life Cycle Database (ELCD),2011

10.7 LCA for the hydro plant

In our case we talk about a hydro plant in Greece and the life cycle consists of 7 subsystems :

1. Raw materials acquisition and materials manufacture

2. Materials transportation

3. Final product use

4. Solid wastes collection and transportation for land field

5. Solid wastes land filling

6. Recycling

7. Reuse

The system is closed because some of the materials will be recycled and will be used for the same cause or for road construction.

Other special conditions ,parameters and assumptions that influence and limit the systems are :

1. The acquisition of raw materials .manufacturing etc takes place in Greece.
2. We use 4 32 tonne trucks to carry the electromechanical materials from Austria to the position of the plant.
3. With a 32 tonne truck we transfer the material from the supplier from Karpenisi to the hydro plant and then with a similar truck we transfer the waste to the aggregate ,metal etc processing company at the 12th km of Old National Road Thessaloniki – Veria.
4. Finally with a 32 tonne truck a proportion of the material that has been used is led in the landfill.

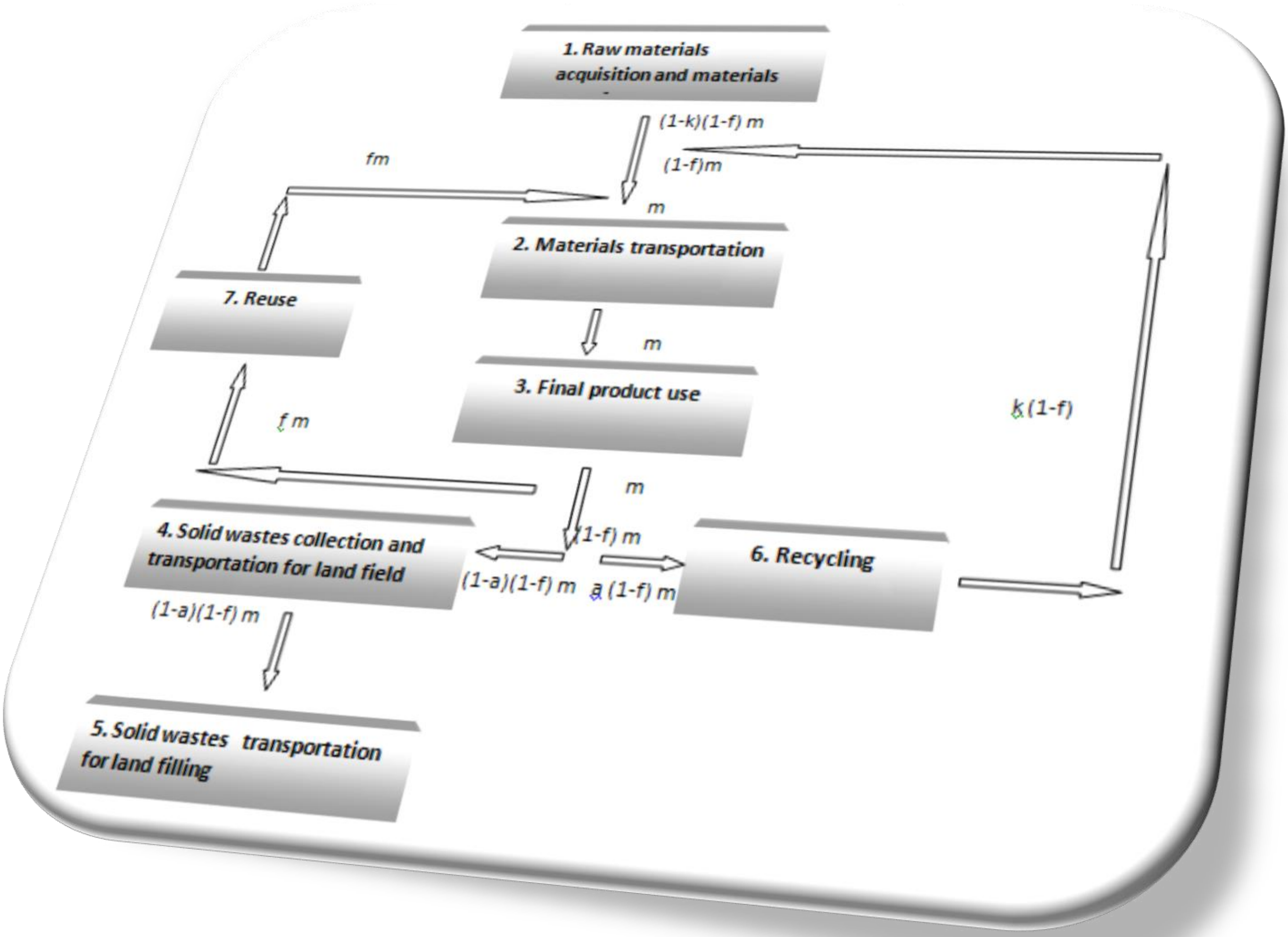


Figure10.17 :Flow chart of our LCA system

10.7.1 Sanitary landfills

Sanitary landfills are the most demanding type of landfill and they are designed to receive all kinds of waste such as untreated municipal or household waste, building wastes, wastewater treatment sludge. Liquid, infectious or radioactive wastes or explosives are not allowed. The landfill design must include base and boundary sealing, a water collection system and also a gas collection system due to the biologically reactive nature of the waste.

For sanitary landfills several stages of development can be discerned.

1. Initial phase: The waste settles and is moistened up. Hydrolysis of hydrocarbons starts.
2. Oxygen and Nitrogen reducing phase: Duration: first two weeks after waste placement.
3. Acidic anaerobic phase: First two months after waste placement.
4. Methane generating anaerobic phase. Further decomposition of hydrocarbons to CO2 and methane (CH4) as landfill gas. The methane phase has an onset time of about 2 years and can last for 30 years.
5. Continuous leaching. While the landfill pH is buffered by acid neutralising materials, the landfill chemistry is in a quasi-steady state. The duration of this phase depends on the acid neutralising capacity of the landfill material and can last thousands of years.
6. Possible pH decrease.
7. Humification and Reoxidation

10.7.2 Emissions from landfills

Emissions to air and water from landfills can be separated into indirect emissions and direct emissions. Indirect emissions occur from the production of used materials and fuels. Direct emissions can be divided into emissions from landfill operations like transports, waste spreading and landfill shaping, and emissions that originate from the waste itself. (Roland Hischie ,Doka G.,2009)

The functional unit of landfill disposal is kilogram of waste.

Table 10.13: Distances of our system

Electromechanical supplier -hydro plant region	1643	km
Raw material supplier-hydro plant	47	km
Hydro plant region-Recycling area	353	km
Hydro plant region-Landfill	53	km

Table 10.14 : Transport types used in LCA and energy and carbon emissions

Transport type		Energy		CO2 and SO2 emission	
32 tonne truck (4)	km	MJ/tonne.km	0,46	kg CO2/tonne.km	0,0326
				kg SO2/tonne.km	0,00006

Table 10.15: Transport types used in LCA and emissions

	Kürer[a] (Germany)		Schoemaker & Bouman[b] (Netherlands)				Whitelegg[c] (Europe)	Befahy[d] (Belgium)	OECD[e] (Europe)
	Local	Long-haul	Trucks	Trucks & Trailers	Truck-tractors & semi-trailers	Road freight overall	Road freight overall	Trucks and semi-trailers > 10 tonnes	Long-distance trucks
CO	1.86	0.25	2.24	0.54	0.34	0.90	2.4	2.10	0.25
CO_2	255	140	451	109	127	211	207		140
HC	1.25	0.32	1.57	0.38	0.34	0.68	0.3[c]	0.92	0.32
NO_x	4.1	3.0	5.65	1.37	2.30	2.97	3.6	1.85	3.0
SO_2	0.32	0.18	0.43	0.10	0.11	0.20	n.a.	n.a.	0.18
Particulates	0.30	0.17	0.90	0.22	0.19	0.39		0.04	0.17
VOC							1.1		

n.a. not available
[a] Kürer 1993, Table 5
[b] Schoemaker and Bouman p. 57, Tables 14 & 15
[c] Whitelegg, John (1993), *Transport for a Sustainable Future -- The case for Europe*, cited in Commission des Communautés Européennes p. 5. HC data are for methane only.
[d] Befahy 1993, Table 4
[e] OECD (1991), *Environmental Policy. How to Apply Economic Instruments*. Cited in OECD (1993), *The Social Costs of Transport* p. 19.

Source: The environmental effects of freight

Table 10.16: Transport types used in LCA and emissions

Pollutant	Truck	Rail	Marine
CO	0.25 - 2.40	0.02 - 0.15	0.018 - 0.20
CO_2	127 - 451	41 - 102	30 - 40
HC	0.30 - 1.57	0.01 - 0.07	0.04 - 0.08
NO_x	1.85 - 5.65	0.20 - 1.01	0.26 - 0.58
SO_2	0.10 - 0.43	0.07 - 0.18	0.02 - 0.05
Particulates	0.04 - 0.90	0.01 - 0.08	0.02 - 0.04
VOC	1.10	0.08	0.04 - 0.11

Source: The environmental effects of freight

Then there will be a collection of data of input-output analysis, in order to construct a Pivot Table, so we can calculate the mass flow at all stages of the lifecycle from extraction until final use.

The main equations used for the measurement of energy, mass, waste and air pollutants are:

$$E=(e1)((1-k)(1-f))m+ +(e2+e3)m+(e4+e5)((1-a)(1-f))m+e6(a(1-f))m+e6(k(1-f)m+e7(f)m$$

f: Percentage of reuse

a: Percentage of recycling

k: Percentage of recycled material

For concrete f=0%, a=23% and k=5%

For steel f=0%, a=100% and k=100%

For aggregates f=5%, a=30% and k=5%.

Table 10.17: LCA Results for steel

Steel(Kaplan)

E=(e1)((1-k)(1-f))m+ (e2+e3)m+(e4+e5)((1-a)(1-f))m+e6(a(1-f))m+e6(k(1-f)m+e7(f)m

		Energy		CO2		So2	
e1	Raw materials acquisition and materials manufacture	11,9	MJ/kg	0,9	kg/kg	0,0052	kg/kg
e2	Steel transportation	0,75578	MJ/kg	0,0535618	kg/kg	0,00009858	kg/kg
e3	Final use	0	MJ/kg	0	kg/kg	0	kg/kg
e4	Solid wastes collection and transportation for landfilling	0,02438	MJ/kg	0,0017278	kg/kg	0,00000318	kg/kg
e5	**Solid wastes landfilling**	0	MJ/kg	0	kg/kg	0	kg/kg
e6	Recycling/Transfer	0,16238	MJ/kg	0,0115078	kg/kg	0,00002118	kg/kg
ε7	Reuse	0,0000069	MJ/kg	0,00000489	kg/kg	0,000000009	kg/kg
		59429,7		4211,757		7,7517	

	Phospete		Ethene		NMVOC		Nox		PPM	
e1	0,000282	kg/kg	0,00035	kg/kg	1	kg/kg	0,00005	kg/kg	0,00003375	kg/kg
e2	0	kg/kg	0	kg/kg	1,07184E-06	kg/kg	0,3286	kg/kg	0	kg/kg
e3	0	kg/kg	0	kg/kg	5,74328E-05	kg/kg	0,003	kg/kg	0	kg/kg
e4	0	kg/kg	0	kg/kg	1,07184E-06	kg/kg	0,00689	kg/kg	1,3939	kg/kg
e5	0	kg/kg	0	kg/kg	1	kg/kg	0	kg/kg	0	kg/kg
e6	0	kg/kg	0	kg/kg	1,07184E-06	kg/kg	0,00611	kg/kg	0	kg/kg
ε7	0	kg/kg	0	kg/kg	1,07184E-06	kg/kg	0,00611	kg/kg	0	kg/kg
	0		0		3,3356554		18910,1		0	

Table 10.18 : LCA Results for concrete

Concrete

E=(e1)((1-k)(1-f))m+ (e2+e3)m+(e4+e5)((1-a)(1-f))m+e6(a(1-f))m+e6(k(1-f)m+e7(f)m

		Energy		CO2		So2	
e1	Raw materials acquisition and materials manufacture	4,749	MJ/kg	3,828	kg/kg	0,0034	kg/kg
e2	Concrete transportation	0,133	MJ/kg	0,0015322	kg/kg	0,00000282	kg/kg
e3	Final use	0	MJ/kg	0	kg/kg	0	kg/kg
e4	Solid wastes collection and transportation for landfilling	0	MJ/kg	0,00383318	kg/kg	0,00000318	kg/kg
e5	**Solid wastes landfilling**	0,04374	MJ/kg	0,0089	kg/kg	0	kg/kg
e6	Recycling/Transfer	0	MJ/kg	0,0115078	kg/kg	0,00002118	kg/kg
ε7	Reuse		MJ/kg	-0,5	kg/kg	0	kg/kg
		11938,842		9317,7576		8,271539848	

Phospete		Ethene		NMVOC		Nox		PPM	
0	kg/kg	0	kg/kg	0,000045	kg/kg	0,0011	kg/kg	0	kg/kg
0	kg/kg	0	kg/kg	1,07184E-06	kg/kg	0,4929	kg/kg	0	kg/kg
0	kg/kg	0	kg/kg	5,74328E-05	kg/kg	0,003	kg/kg	0	kg/kg
0	kg/kg	0	kg/kg	2,11718E-05	kg/kg	0,007048	kg/kg	0,0000327	kg/kg
0	kg/kg	0	kg/kg	0,0000356	kg/kg	0,000169	kg/kg	0,0000155	kg/kg
0	kg/kg	0	kg/kg	1,07184E-06	kg/kg	0,00611	kg/kg	0	kg/kg
0	kg/kg	0	kg/kg	1,07184E-06	kg/kg	0,00611	kg/kg	0	kg/kg
0		0		0,37072657		1286,751		0,0947149	

Table 10.19 : LCA Results for aggregates

	Aggregates						
	E=(e1)((1-k)(1-f))m+ (e2+e3)m+(e4+e5)((1-a)(1-f))m+e6(a(1-f))m+e6(k(1-f)m+e7(f)m						
		Energy		CO2		So2	
e1	Raw materials acquisition and materials manufacture	0	MJ/kg	0,003285	kg/kg	0,00001885	kg/kg
e2	Aggregate transportation	0,0548333	MJ/kg	0,0015322	kg/kg	0,00009858	kg/kg
e3	Final use	0	MJ/kg	0	kg/kg	0	kg/kg
e4	Solid wastes collection and transportation for landfilling	0,0618333	MJ/kg	0,37540532	kg/kg	0,0000318	kg/kg
e5	**Solid wastes landfilling**	0,03594	MJ/kg	0	kg/kg	0	kg/kg
e6	Recycling/Transfer	0,4118333	MJ/kg	0,0115078	kg/kg	0,00002118	kg/kg
ε7	Reuse	0	MJ/kg	0,00000489	kg/kg	0,000000009	kg/kg
		130,95119		1350,129		7,7517	

Phospete		Ethene		NMVOC		Nox		PPM	
0	kg/kg	0	kg/kg	0,0001125	kg/kg	0,0005	kg/kg	0,0000835	kg/kg
0	kg/kg	0	kg/kg	1,07184E-06	kg/kg	0,4929	kg/kg	0	kg/kg
0	kg/kg	0	kg/kg	5,74328E-05	kg/kg	0,003	kg/kg	0	kg/kg
0	kg/kg	0	kg/kg	0,001219534	kg/kg	0,002675	kg/kg	6,18774E-05	kg/kg
0	kg/kg	0	kg/kg		kg/kg	0	kg/kg	0	kg/kg
0	kg/kg	0	kg/kg	1,07184E-06	kg/kg	0,00611	kg/kg	0	kg/kg
0	kg/kg	0	kg/kg	1,07184E-06	kg/kg	0,00611	kg/kg	0	kg/kg
0		0		3,3356554		27946,6		0	

10.8 Conclusions

The use of construction waste nowadays appears particularly attractive because of the environmental benefits arising from the use of such refuse. Especially in Greece, where the establishment of organized systems of alternative waste management building located just around the corner, it seems the trend of dynamic penetration of recycled materials in existing markets aggregates.

The potential use of materials from demolition of buildings as raw materials in the cement industry, must become a point of discussion. Since the cement industry are facing or will face in the future problems concerning the discovery of raw materials and energy saving, these materials could be one possible solution to the problem.

Chapter 11- Financial analysis and evaluation of the investment

10.1 Total Investment Cost

The total cost consists of costs related to preparatory productive costs, handling paperwork, equipment manufacturers, service equipment and civil works. The total investment cost for the construction of a hydro power plant is presented in the equation below.

Total investment cost= Fixes assets + Net working capital

10.1.1 Net working capital

The formula for net working capital (NWC) is used to determine the availability of a company's liquid assets by subtracting its current liabilities.

Current Assets are the assets that are available within 12 months. Current Liabilities are the liabilities that are due within 12 months.

Net working capital is calculated as current assets minus current liabilities. It is a derivation of working capital, that is commonly used in valuation techniques such as Discounted cash flows. *If current assets are less than current liabilities, an entity has a working capital deficiency, also called a working capital deficit.*

A company can be endowed with assets and profitability but short of liquidity if its assets cannot readily be converted into cash. Positive working capital is required to ensure that a firm is able to continue its operations and that it has sufficient funds to satisfy both maturing short-term debt and upcoming operational expenses.

The current assets include receivables, inventories (goods Raw materials, consumables, etc.) and cash.

Due to the size and nature of the investment, almost all of the data, which constitute the working capital (receivables, inventories creditors), not generated during any phase of this investment.

The only factor that there is a rudimentary amount of cash in the- minus, which covers the few operational needs of the unit. On this basis, we assume that there will be no capital.

10.1.2 Fixed assets

Fixed asset is an asset that is not consumed or sold during the normal course of business, such as land, buildings, equipment, machinery, vehicles, leasehold improvements, and other such items.

Fixed assets enable their owner to carry on its operations. In accounting, fixed does not necessarily mean immovable; any asset expected to last, or be in use for, more than one year is considered a fixed asset. On a balance sheet, these assets are shown at their book value (purchase price less depreciation).

10.2 Total Investment Cost

The total cost consists of costs related to preparatory productive costs, handling paperwork, equipment manufacturers, service equipment and civil works. The total investment cost for the construction of power plants from hydro energy is presented in the table below.

Table 11.1: Total Investment Cost

	Chapter	Total Cost
Market- research- trips	2	8000
Preliminary study of feasibility	2	18000
Feasibility Study	2	40000
Environmental study	8	10.000
Preliminary studies of the land	8	8.000
Civil engineering projects	5	1415854
Steel structures	5	85000
Electromechanical equipment	5	1862112,5
Street access	5	5670
Interconnection with the national grid	5	110163
Cost of land	5,6,8	138000
Legal and other costs/	8	15.000
Receiving required permits	8	30.000
Human Resources Training	8	6.000
Total		**3751799,5**

11.3 Financing Program

This section will indicate the sources of investment the program. This investment effort will build on Development Law N.3299/04 on investment and subsidy.

The development law provides funding of 40% of aided expenditure, assuming equity correspond least 25% of the recipients expenditure.

We take into account 4 scripts. The first and the second one doesn't take into consideration the environmental impact in economical value.

In the third and fourth scenario we try to present quantifiable external costs related to the operation of emerging electricity generation technologies.It provides external cost estimates for typical average configurations thus indicating the order of magnitude of externalities from future electricity generation technologies. *The quantification of external costs is based on the 'impact pathway' methodology which has been developed in the series of ExternE projects, and is further improved within NEEDS and other related projects.*

The impacts resulting from the emission of a pollutant partly depend on the location of the emission source, the release height, and the concentration of other pollutants in the environment. Taking these different parameters into account, based on detailed model runs RS1b/RS3a produced a set of unit damage costs (damage costs per tonne of pollutant emitted) which differ by the emission source country (all European countries, EU27 average), by release height (average release height, low release height, high release height), and by the year of the background emissions (2010 and 2020).

Table 11.2: Impact categories and pollutants covered by the NEEDS methodology for quantifying external costs from airborne pollutants

Impact	Pollutants
Human health	fine particles, NOx, SO_2, NMVOC, NH_3, Cd, As, Ni, Pb, Hg, Cr, Formaldehyde, Dioxin, several radionuclides
Loss of biodiversity	NH_3, NMVOC, NOx, SO_2
Crop yield	SO_2, NOx
Material damage	SO_2, NOx

Source: European Commission within the Sixth Framework Programme,2006

The unit damage costs used for quantifying externalities from some airborne pollutants are summarised in Table 11.3.

Table 11.3: Unit damage costs for air pollutants in €2000 per elementary flow

		Emissions in 2010				Emissions in 2020			
		health	biodiversity	crop yield	material damage	health	biodiversity	crop yield	material damage
Emissions to air									
NH_3	€/t	9485	3409	-183		5840	3440	-183	
NMVOC	€/t	941	-70	189		595	-50	103	
NOx	€/t	5722	942	328	71	6751	906	435	131
PPM_{CO} (2.5-10 µm)	€/t	1327				1383			
$PPM_{2.5}$ (< 2.5 µm)	€/t	24570				24261			
SO_2	€/t	6348	184	-39	259	6673	201	-54	259

Source: European Commission within the Sixth Framework Programme,2006

Table 11.4: Marginal damage costs of greenhouse gas emissions in €/t (Values for average 1% trimmed, discounted to 2005, 1% pure rate of time preference, without equity weighting and with equity weighting normalised to Western European average per capita income, 1.35 $ per €)

	2005	2025	2045
CO_2			
without equity weighting	7	7	5
with equity weighting	98	86	52
CH_4			
without equity weighting	310	238	193
with equity weighting	3562	2648	2080

Source: European Commission within the Sixth Framework Programme,2006

Table 11.5:Total amount of ton in our study

	CO2	SO2	NMVOC	NOx	PPM
CONCRETE	9,318	0,00827	0,003707	1,287	0,000095
STEEL	4,21	0,00775	0,00336	18,91	0
AGGREGATE	1,350129	0,007752	0,003336	2,7946	0
TOTAL(ton)	14,878129	0,023772	0,010403	22,9916	0,000095

Table 11.6: Marginal costs for greenhouse from emissions and pollutants

	Marginal costs for greenhouse gas emissions				
CO_2		93	€/t	**1383,666**	€
	Unit damage costs for air pollutants				
NMVOC	Health	941	€/t	9,788847	
	Biodiversity	-70	€/t	-0,72818	
	Crop yield	189	€/t	1,966091	
	Material damage	0	€/t	0	
				11,02676	€
Nox	Health	5722	€/t	131557,9	
	Biodiversity	942	€/t	21658,09	
	Crop yield	328	€/t	7541,245	
	Material damage	71	€/t	1632,404	
				162389,7	€
PPM	Health	1327	€/t	0,126065	
	Biodiversity	0	€/t	0	
	Crop yield	0	€/t	0	
	Material damage	0	€/t	0	
				0,126065	€
SO_2	Health	6348	€/t	150,9028	
	Biodiversity	184	€/t	4,373993	
	Crop yield	-39	€/t	-0,9271	
	Material damage	259	€/t	6,15687	
				160,5065	€
	TOTAL			**163945**	€

Table 11.7: Total Investment Cost plus Environmental cost from emissions

Total cost	
Market- research- trips	8000
Preliminary study of feasibility	18000
Feasibility Study	40000
Environmental study	10.000
Preliminary studies of the land	8.000
Civil engineering projects	1415854
Steel structures	85000
Electromechanical equipment	1862112,5
Street access	5670
Interconnection with the National grid	110163
Cost of land	138000
Legal and other costs/	15.000
Receiving required permits	30.000
Human Resources Training	6.000
	3751799,5
Environmental study (2)	163944,996
Total	3915744,5

Based on the above, the financing scheme is proposed to consist of the below parts:

Table 11.8: Sources of Funding for the Investment Program (1st scenario)

1st SCENARIO			
	Percentage	(€)	Amount
EQUITY	25	%	937949,875
SUBSIDY	40	%	1500719,8
LENDING	35	%	1313129,825

Table 11.9: Sources of Funding for the Investment Program (2nd scenario)

2nd SCENARIO			
	Percentage		Amount (€)
EQUITY	60	%	2251079,7
SUBSIDY	40	%	1500719,8
LENDING	0	%	0

Table 11.10: Sources of Funding for the Investment Program (3rd scenario)

3rd SCENARIO			
	Percentage		Amount (€)
EQUITY	25	%	978936,124
SUBSIDY	40	%	1566297,798
LENDING	35	%	1370510,574

Table 11.11: Sources of Funding for the Investment Program (4th scenario)

4th SCENARIO			
	Percentage		Amount (€)
EQUITY	60	%	2349446,698
SUBSIDY	40	%	1566297,798
LENDING	0	%	0

11.4 Amortization Liabilities

The Amortizatin Liabilities which is related to the finance part , will be covered by the Banking Agency. The percentage of total investment cost which will come from a bank loans is 35%, will correspond to the amount of 1313129,825 € in the first scenario and 1370510,574€ in the third one. Funding will start at the beginning of the new investment and the repayment liabilities lasts 10 years.

11.4.1 Loan features

Table 11.12: Loan features

Amount of Loan	**1313130**
Annual Interest	9%
Duration	10 years

The monthly installment will be 16720 € with a nominal interest rate of 9,12% (0,12% - units contributions of Law 128/75)

Table 11.13: Total annual installments for 1st scenario

Year	Total annual installments	Annual paid up capital(C-B_)	Annual interest payments(A-B)	Balance (outstanding balance)	Interest (interest rate 9%)
				1313129,825	
2014	200640	84345,24	116294,76	1228784,585	84345,24
2015	200634,87	92367,35	108267,52	1136417,235	92367,35
2016	200634,87	101152,44	99482,43	1035264,795	101152,44
2017	200634,87	110773,09	89861,78	924491,705	110773,09
2018	200634,87	121308,77	79326,1	803182,935	121308,77
2019	200634,87	132846,49	67788,38	670336,445	132846,49
2020	200634,87	145481,58	55153,29	524854,865	145481,58
2021	200634,87	159318,39	41316,48	365536,475	159318,39
2022	200634,87	174471,23	26163,64	191065,245	174471,23
2023	200634,87	191065,25	9569,62	-0,005	191065,25
Sum	2006353,83	1313129,83	693224	6879934,28	**1313129,83**

10.5 Sales Revenue

The sales revenue for the first decade is expected to be stable, as the market price of KWh (Feed in tariff) of the Public Power Corporation is constant.

The fixed price sale of electricity combined with the almost perfectly predicted production (deviations of 10%) of electricity, was calculated at **13787256** KWh per year, gives us the result of revenue sales.

We believe that energy production of 15 MW every year remains constant while the income of the company is revalued by 3.5% revalued as inflation as shown in the table in Chapter 3.

Annual revenues hydroelectric by applying price increases on Budgets

	Energy produced (GWh)	Annual income (€)
Year 1	15	1.317.750
Year 2	15	1363871,25
Year 3	15	1411606,744
Year 4	15	1461012,98
Year 5	15	1512148,434
Year 6	15	1565073,629
Year 7	15	1619851,206
Year 8	15	1676545,999
Year 9	15	1735225,108
Year 10	15	1795957,987
Year 11	15	1858816,517
Year 12	15	1923875,095
Year 13	15	1991210,723
Year 14	15	2060903,099
Year 15	15	2133034,707
Year 16	15	2207690,922
Year 17	15	2284960,104
Year 18	15	2364933,708
Year 19	15	2447706,387
Year 20	15	2533376,111

10.6 Cost of Production

Below, we have calculated the cost of production for the first ten years operation of the unit.

Depreciation is the accounting determination of damage caused to the value of assets to use or over time. The practice of depreciation involves the removal of a certain amount from the gross annual earnings in basis until the sum of annual depreciation is equal to the market value fixed assets.

There are detailed depreciation of fixed assets investment. The factors for depreciation that have been made are:

- For the production equipment production facility the lower depreciation rate is five percent (4%) and the upper- than seven percent (6%). In our case we will use the 4% for 5 years.
- For Civil Engineering (foundation, fencing), the rate is 4% for five years.
- The transport costs of production equipment increases the acquisition cost of equipment and therefore consolidated with the cost of production equipment. So, and in this case be used to 0,15% .(it has been incorporated from chapter 5)

Table 11.14: Depreciation and amortization of fixed cost

Land	0 %
Machines and faclities	4 %

Table 11.15:Total cost with depreciaton the first five yeas

	Civil engineering projects	Electromechanical equipment	Total cost
	1415854	1862112,5	
2014	56634,16	74484,5	131118,66
2015	56634,16	74484,5	131118,66
2016	56634,16	74484,5	131118,66
2017	56634,16	74484,5	131118,66
2018	56634,16	74484,5	131118,66
	283170,8	372422,5	

11.7 Production Cost

Table 11.16: Cost of Production

	Annual general expenses for workforce(€)	Annual cost for raw materials etc(€)	Annual general expenses (€)	Interest rate 9%	Depreciation and amortization of fixed	SUM
2014	238000	100289	340546	84345	131119	894299
2015	246330	103799	352465	92367	131119	926080
2016	254952	107432	364801	101152	131119	959456
2017	263875	111192	377569	110773	131119	994528
2018	273110	115084	390784	121309	131119	1031406
2019	282669	119112	404461	132846	131119	1070208
2020	292563	123281	418618	145482	131119	1111061
2021	302802	127596	433269	159318	131119	1154104
2022	313401	132061	448434	174471	131119	1199485
2023	324370	136684	464129	191065	131119	1247366
2024	335723	141468	480373	0	131119	1088682
2025	347473	146419	497186	0	131119	1122197
2026	359634	151544	514588	0	131119	1156884
2027	372222	156848	532598	0	131119	1192786
2028	385249	162337	551239	0	131119	1229945
2029	398733	168019	570533	0	131119	1268403
2030	412689	173900	590501	0	131119	1308208
2031	427133	179986	611169	0	131119	1349407
2032	442082	186286	632560	0	131119	1392047
2033	457555	192806	654699	0	131119	1436179

10.7 Financial Review

10.7.1 Performance Period Capital (Payback Period)

The Performance Period is the capital payback of initial capital investment through profits of the investment program. Here, the benefit is defined as the Net Profit after tax plus financing costs and depreciation.

The table below gives the evolution of the profits of the investment program the first twenty years of operation of the unit.

Table 11.17: Income statement (1^{ST} Scenario)

Income statement

	Annual income (€)	Production cost	Depreciation and amortization of fixed	Profits before tax on	Interest rate9%
2014	1317750	928135	131119	258496	84345
2015	1363871	944303	131119	288449	92367
2016	1411607	960581	131119	319907	101152
2017	1461013	976929	131119	352966	110773
2018	1512148	993301	131119	387729	121309
2019	1565074	1009648	131119	424307	132846
2020	1619851	1025910	131119	462823	145482
2021	1676546	1042023	131119	503405	159318
2022	1735225	1057913	131119	546194	174471
2023	1795958	1073496	131119	591343	191065
2024	1858817	1088682	131119	639016	0
2025	1923875	1122197	131119	670560	0
2026	1991211	1156884	131119	703208	0
2027	2060903	1192786	131119	736998	0
2028	2133035	1229945	131119	771971	0
2029	2207691	1268403	131119	808169	0
2030	2284960	1308208	131119	845633	0
2031	2364934	1349407	131119	884408	0
2032	2447706	1392047	131119	924541	0
2033	2533376	1436179	131119	966078	0

Pofits after interest	Tax(25%)	Net profit after interest and tax	Dividend shares	Reserve	net cash flow	Cumulative net cash flow
174151	43538	130613	78368	52245	261732	236355
196082	49021	147062	88237	58825	278180	514535
218755	54689	164066	98440	65626	295185	809720
242193	60548	181644	108987	72658	312763	1122483
266420	66605	199815	119889	79926	330933	1453416
291461	72865	218596	131157	87438	349714	1803131
317341	79335	238006	142803	95202	369124	2172255
344086	86022	258065	154839	103226	389183	2561438
371723	92931	278792	167275	111517	409911	2971349
400278	100069	300208	180125	120083	431327	3402676
639016	159754	479262	287557	191705	610381	4013056
670560	167640	502920	301752	201168	634038	4647095
703208	175802	527406	316443	210962	658524	5305619
736998	184250	552749	331649	221099	683867	5989487
771971	192993	578979	347387	231591	710097	6699584
808169	202042	606127	363676	242451	737245	7436829
845633	211408	634225	380535	253690	765343	8202173
884408	221102	663306	397984	265323	794425	8996598
924541	231135	693406	416043	277362	824524	9821122
966078	241520	724559	434735	289823	855677	10676799

We can notice how the Performance Period of the Fund is quite large .For this reason, the State and the European Union are leveraging this type of investment (RES-'green' investments) through state grants. And in the case of this investment program, 35% of the total investment cost is a state grant.

As economic life cycle of an investment is the period when the during which recovered the initial capital investment and the desired performance of this. The economic life cycle must be equal to or less than the Real-life of key equipment investment.

In this case the Performance Period of the Fund is 8 to 9 years, which is considered a good Performance Period of the Fund.

10.7.2 Net Present Value

For the calculation of the Net Present Value of the investment will be made some cases as there are practical problems in realistic calculation.

The formula which is used in the calculation of NPV is:

$$ΚΠΑ = \sum_{T=1}^{v} [Κ.Τ.Ρ_{Τ} *(ΣΠΑ_{κ.ν})] - Κ.Ε$$

NPV = Net Present Value

KTRt = net cash flow in the period

CM = Cost of Investment

R = Minimum Acceptable Return (Weighted Average Cost of Capital)

N = Number of periods

We should calculate the net cash flows for the years 11-20 of investment programe, defined as net profit, adding Depreciation of each period.

This calculation is difficult , however, as for the second decade of life the investment program has not given the exact price of Electricity Energy produced by the unit and will be available at the Public Corporation Electricity from its operator.

Our calculations will be done with the default price of H / E (feed in tariff).

With these assumptions we consider the calculation of the Net Present Value made as realistic as possible.

The method of NPV based on discounting of future net cash flows. The methods are based on discounting, take account both the size and timing of net cash flows expected by each period of the life of the investment (time value of money)

With this method the NPV (Net Present Value method), all net cash flows are discounted to the present (time 0), the rate discounted with the minimum acceptable return (weighted average cost of capital).

If the NPV is greater than or equal to zero, then the investment proposal is accepted. In the case of this investment program we have:

Table 11.18 :NPV

Net present value method

	Net cash flow	Present value factor(9%)	Present value	Net Present Value
2014	236354,6749	0,917431193	216839,1513	-3534960,349
2015	264512,8109	0,841679993	222635,1409	-3312325,208
2016	294340,9352	0,77218348	227285,2077	-3085040
2017	325962,5953	0,708425211	230920,1204	-2854119,88
2018	359511,856	0,649931386	233658,039	-2620461,841
2019	395134,2548	0,596267327	235605,6459	-2384856,195
2020	432987,8458	0,547034245	236859,1792	-2147997,016
2021	473244,3499	0,50186628	237505,3813	-1910491,634
2022	516090,4006	0,46042778	237622,3572	-1672869,277
2023	561728,9171	0,422410807	237280,3651	-1435588,912
2024	610380,5971	0,38753285	236542,5326	-1199046,38
2025	634038,4945	0,355534725	225422,7019	-973623,6777
2026	658524,4184	0,326178647	214796,6037	-758827,0739
2027	683867,3496	0,299246465	204644,8869	-554182,187
2028	710097,2834	0,274538041	194948,7173	-359233,4697
2029	737245,2648	0,251869763	185689,7899	-173543,6798
2030	765343,4257	0,231073177	176850,3367	3306,656861
2031	794425,0221	0,21199374	168413,1317	171719,7886
2032	824524,4744	0,19448967	160361,4928	332081,2814
2033	855677,4076	0,17843089	152679,2812	484760,5626
			4236560,063	

So the investment proposal is accepted.

10.7.3 Internal Rate of Return (IRR)

The internal rate of return on investment is the rate at which the Present value of cash inflows equal to the present value of cash outflows. To calculate the internal rate of return with the following process:

- Calculate the cash flows, as was done for the calculation of the Net Present Value.
- There is discounting the NPV, but with the given rate of the capital market, but with different rates.
- When the use of a lower interest rate yield positive NPV (IRR1), try to a higher one. If this be the NPV negative, (IRR2), the IRR is accurate

The two interest rates by type:

$$IRR = IRR1 + \frac{\Theta NPV * (IRR2 - IRR1)}{\Theta NPV - ANPV}$$

Where

ΘNPV = Positive Net Present Value

ANPV = Negative Net Present Value

The result reflects the higher rate could be paid by the investor without danger of losing all the money allocated for investment, even if it has borrowed all the money.

Table 11.19: IRR

Internal rate of return method IRR

	Net cash flow	(12%)	(6%)	Present value12%	Present value 6%	Net present value (12%)	Net present value (6%)
2014	236354,67	0,89	0,94	211030,96	222976,11	-3540768,54	-3528823,39
2015	264512,81	0,80	0,89	210867,99	235415,46	-3329900,55	-3293407,93
2016	294340,94	0,71	0,84	209506,06	247134,32	-3120394,48	-3046273,61
2017	325962,60	0,64	0,79	207155,12	258192,91	-2913239,36	-2788080,70
2018	359511,86	0,57	0,75	203996,68	268648,17	-2709242,68	-2519432,53
2019	395134,25	0,51	0,70	200187,31	278554,06	-2509055,37	-2240878,47
2020	432987,85	0,45	0,67	195861,71	287961,65	-2313193,66	-1952916,82
2021	473244,35	0,40	0,63	191135,46	296919,36	-2122058,20	-1655997,46
2022	516090,40	0,36	0,59	186107,37	305473,12	-1935950,83	-1350524,35
2023	561728,92	0,32	0,56	180861,68	313666,49	-1755089,15	-1036857,85
2024	610380,60	0,29	0,53	175469,84	321540,88	-1579619,31	-715316,97
2025	634038,49	0,26	0,50	162741,89	315097,71	-1416877,43	-400219,26
2026	658524,42	0,23	0,47	150916,80	308741,94	-1265960,62	-91477,32
2027	683867,35	0,20	0,44	139932,81	302475,19	-1126027,82	210997,87
2028	710097,28	0,18	0,42	129732,12	296298,79	-996295,70	507296,66
2029	737245,26	0,16	0,39	120260,67	290213,86	-876035,02	797510,51
2030	765343,43	0,15	0,37	111467,94	284221,32	-764567,09	1081731,83
2031	794425,02	0,13	0,35	103306,70	278321,87	-661260,38	1360053,70
2032	824524,47	0,12	0,33	95732,88	272516,07	-565527,50	1632569,77
2033	855677,41	0,10	0,31	88705,31	266804,26	-476822,19	1899374,03

It is obvious that interest rates could be > than 9% .Somewhere between 9 and 12%. So the unit under review is attractive.

10.7.5 Return on investment (ROI)

ROI is a performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments. It is one way of considering profits in relation to capital invested.

The purpose of the "return on investment" metric is to measure, per period, rates of return on money invested in an economic entity in order to decide whether or not to undertake an investment.

ROI and related metrics provide a snapshot of profitability, adjusted for the size of the investment assets tied up in the enterprise. ROI is often compared to expected (or required) rates of return on money invested.

Marketing decisions have obvious potential connection to the numerator of ROI (profits), but these same decisions often influence assets usage and capital requirements (for example, receivables and inventories). Marketers should understand the position of their company and the returns expected.

$$\text{ROI} = \frac{(\text{Gain from Investment} - \text{Cost of Investment})}{\text{Cost of Investment}}$$

Table 11.20: ROI

ROI

	Net profit after interest and tax	
2014	130613,3	3,481352
2015	147061,6	3,919762
2016	164066,1	4,372998
2017	181644,5	4,84153
2018	199814,8	5,325839
2019	218595,6	5,826419
2020	238005,7	6,343775
2021	258064,6	6,878422
2022	278792	7,430888
2023	300208,2	8,001713
2024	479261,9	12,77419
2025	502919,8	13,40476
2026	527405,8	14,05741
2027	552748,7	14,7329
2028	578978,6	15,43202
2029	606126,6	16,15562
2030	634224,8	16,90455
2031	663306,4	17,67969
2032	693405,8	18,48195
2033	724558,7	19,3123

As we can see the ROI above is satisfactory.

The same evaluation procedure is set out for the other three scenarios.

Table 11.21: Cost production (2nd Scenario)

Production cost

	Annual general expenses for workforce(€)	Annual cost for raw materials etc(€)	Annual general expenses (€)	Interest (interest rate9%)	Depreciation and amortization of fixed	SUM
2014	238000	100289	340545,625	0	131118,66	809953,285
2015	246330	103799,115	352464,7219	0	131118,66	833712,4969
2016	254951,55	107432,084	364800,9871	0	131118,66	858303,2812
2017	263874,8543	111192,207	377569,0217	0	131118,66	883754,7429
2018	273110,4741	115083,9342	390783,9374	0	131118,66	910097,0058
2019	282669,3407	119111,8719	404461,3753	0	131118,66	937361,2479
2020	292562,7677	123280,7874	418617,5234	0	131118,66	965579,7385
2021	302802,4645	127595,615	433269,1367	0	131118,66	994785,8762
2022	313400,5508	132061,4615	448433,5565	0	131118,66	1025014,229
2023	324369,5701	136683,6127	464128,731	0	131118,66	1056300,574
2024	335722,505	141467,5391	480373,2366	0	131118,66	1088681,941
2025	347472,7927	146418,903	497186,2998	0	131118,66	1122196,656
2026	359634,3404	151543,5646	514587,8203	0	131118,66	1156884,385
2027	372221,5424	156847,5893	532598,394	0	131118,66	1192786,186
2028	385249,2963	162337,255	551239,3378	0	131118,66	1229944,549
2029	398733,0217	168019,0589	570532,7147	0	131118,66	1268403,455
2030	412688,6775	173899,7259	590501,3597	0	131118,66	1308208,423
2031	427132,7812	179986,2164	611168,9073	0	131118,66	1349406,565
2032	442082,4285	186285,7339	632559,819	0	131118,66	1392046,641
2033	457555,3135	192805,7346	654699,4127	0	131118,66	1436179,121

Table 11.22: Income statement

Annual income (€)	Production cost	Depreciation and amortization of fixed	Profits before tax on	Profits after interest	Tax(25%)	Net profit after interest and tax
1317750	809953	131119	376678	376678	94170	282509
1363871	833712	131119	399040	399040	99760	299280
1411607	858303	131119	422185	422185	105546	316639
1461013	883755	131119	446140	446140	111535	334605
1512148	910097	131119	470933	470933	117733	353200
1565074	937361	131119	496594	496594	124148	372445
1619851	965580	131119	523153	523153	130788	392365
1676546	994786	131119	550641	550641	137660	412981
1735225	1025014	131119	579092	579092	144773	434319
1795958	1056301	131119	608539	608539	152135	456404
1858817	1088682	131119	639016	639016	159754	479262
1923875	1122197	131119	670560	670560	167640	502920
1991211	1156884	131119	703208	703208	175802	527406
2060903	1192786	131119	736998	736998	184250	552749
2133035	1229945	131119	771971	771971	192993	578979
2207691	1268403	131119	808169	808169	202042	606127
2284960	1308208	131119	845633	845633	211408	634225
2364934	1349407	131119	884408	884408	221102	663306
2447706	1392047	131119	924541	924541	231135	693406
2533376	1436179	131119	966078	966078	241520	724559

Dividend shares	Reserve	Net cash flow	Cumulative net cash flow
169505	113003	413627	236355
179568	119712	430399	666753
189983	126655	447757	1114511
200763	133842	465723	1580234
211920	141280	484318	2064552
223467	148978	503564	2568116
235419	156946	523483	3091599
247789	165192	544100	3635699
260591	173728	565438	4201137
273842	182562	587523	4788660
287557	191705	610381	5399040
301752	201168	634038	6033079
316443	210962	658524	6691603
331649	221099	683867	7375471
347387	231591	710097	8085568
363676	242451	737245	8822813
380535	253690	765343	9588157
397984	265323	794425	10382582
416043	277362	824524	11207106
434735	289823	855677	12062784

In this case the Performance Period of the Fund is 7 to 8 years, which is considered a good Performance Period of the Fund.

Table 11.23: ROI

SIMPLE METHOD PERFORMANCE FACTOR CAPITAL(ASA)

	Net profit after interest and tax	Interest	SUM	ASA	ASAm
2014	130613,3481	0	130613,3481	3,48	5,80
2015	147061,5979	0	147061,5979	3,92	6,53
2016	164066,1086	0	164066,1086	4,37	7,29
2017	181644,4915	0	181644,4915	4,84	8,07
2018	199814,8086	0	199814,8086	5,33	8,88
2019	218595,5754	0	218595,5754	5,83	9,71
2020	238005,7108	0	238005,7108	6,34	10,57
2021	258064,6008	0	258064,6008	6,88	11,46
2022	278792,0302	0	278792,0302	7,43	12,38
2023	300208,2236	0	300208,2236	8,00	13,34
2024	479261,9371	0	479261,9371	12,77	21,29
2025	502919,8345	0	502919,8345	13,40	22,34
2026	527405,7584	0	527405,7584	14,06	23,43
2027	552748,6896	0	552748,6896	14,73	24,55
2028	578978,6234	0	578978,6234	15,43	25,72
2029	606126,6048	0	606126,6048	16,16	26,93
2030	634224,7657	0	634224,7657	16,90	28,17
2031	663306,3621	0	663306,3621	17,68	29,47
2032	693405,8144	0	693405,8144	18,48	30,80
2033	724558,7476	0	724558,7476	19,31	32,19

Table 11.24: Cost production (3rd Scenario)

	Annual general expenses for workforce(€)	Annual cost for raw materials etc(€)	Annual general expenses (€)	Interest rate9%	Depreciation and amortization of fixed	SUM
2014	238000,0	100289,0	340545,6	118181,7	131118,7	928135,0
2015	246330,0	103799,1	352464,7	110590,6	131118,7	944303,1
2016	254951,6	107432,1	364801,0	102277,6	131118,7	960580,8
2017	263874,9	111192,2	377569,0	93173,8	131118,7	976928,6
2018	273110,5	115083,9	390783,9	83204,3	131118,7	993301,3
2019	282669,3	119111,9	404461,4	72286,5	131118,7	1009647,7
2020	292562,8	123280,8	418617,5	60330,3	131118,7	1025910,0
2021	302802,5	127595,6	433269,1	47236,9	131118,7	1042022,8
2022	313400,6	132061,5	448433,6	32898,3	131118,7	1057912,5
2023	324369,6	136683,6	464128,7	17195,9	131118,7	1073496,4
2024	335722,5	141467,5	480373,2	0,0	131118,7	1088681,9
2025	347472,8	146418,9	497186,3	0,0	131118,7	1122196,7
2026	359634,3	151543,6	514587,8	0,0	131118,7	1156884,4
2027	372221,5	156847,6	532598,4	0,0	131118,7	1192786,2
2028	385249,3	162337,3	551239,3	0,0	131118,7	1229944,5
2029	398733,0	168019,1	570532,7	0,0	131118,7	1268403,5
2030	412688,7	173899,7	590501,4	0,0	131118,7	1308208,4
2031	427132,8	179986,2	611168,9	0,0	131118,7	1349406,6
2032	442082,4	186285,7	632559,8	0,0	131118,7	1392046,6
2033	457555,3	192805,7	654699,4	0,0	131118,7	1436179,1

Table 11.25:Income statement

	Annual income (€)	Production cost	Depreciation and amortization of fixed	Profits before tax on	Interest rate9%
2014	1317750,0	928135,0	131118,7	258496,4	118181,7
2015	1363871,3	944303,1	131118,7	288449,5	110590,6
2016	1411606,7	960580,8	131118,7	319907,3	102277,6
2017	1461013,0	976928,6	131118,7	352965,7	93173,8
2018	1512148,4	993301,3	131118,7	387728,5	83204,3
2019	1565073,6	1009647,7	131118,7	424307,3	72286,5
2020	1619851,2	1025910,0	131118,7	462822,5	60330,3
2021	1676546,0	1042022,8	131118,7	503404,5	47236,9
2022	1735225,1	1057912,5	131118,7	546193,9	32898,3
2023	1795958,0	1073496,4	131118,7	591342,9	17195,9
2024	1858816,5	1088681,9	131118,7	639015,9	0,0
2025	1923875,1	1122196,7	131118,7	670559,8	0,0
2026	1991210,7	1156884,4	131118,7	703207,7	0,0
2027	2060903,1	1192786,2	131118,7	736998,3	0,0
2028	2133034,7	1229944,5	131118,7	771971,5	0,0
2029	2207690,9	1268403,5	131118,7	808168,8	0,0
2030	2284960,1	1308208,4	131118,7	845633,0	0,0
2031	2364933,7	1349406,6	131118,7	884408,5	0,0
2032	2447706,4	1392046,6	131118,7	924541,1	0,0
2033	2533376,1	1436179,1	131118,7	966078,3	0,0

Profits after interest	Tax(25%)	Net profit after interest and tax	Dividend shares	Reserve	Net cash flow	Cumulative net cash flow
140314,7	35078,7	105236,0	63141,6	42094,4	236354,7	236354,7
177858,9	44464,7	133394,2	80036,5	53357,7	264512,8	500867,5
217629,7	54407,4	163222,3	97933,4	65288,9	294340,9	795208,4
259791,9	64948,0	194843,9	116906,4	77937,6	325962,6	1121171,0
304524,3	76131,1	228393,2	137035,9	91357,3	359511,9	1480682,9
352020,8	88005,2	264015,6	158409,4	105606,2	395134,3	1875817,1
402492,2	100623,1	301869,2	181121,5	120747,7	432987,8	2308805,0
456167,6	114041,9	342125,7	205275,4	136850,3	473244,3	2782049,3
513295,7	128323,9	384971,7	230983,0	153988,7	516090,4	3298139,7
574147,0	143536,8	430610,3	258366,2	172244,1	561728,9	3859868,6
639015,9	159754,0	479261,9	287557,2	191704,8	610380,6	4470249,2
670559,8	167639,9	502919,8	301751,9	201167,9	634038,5	5104287,7
703207,7	175801,9	527405,8	316443,5	210962,3	658524,4	5762812,2
736998,3	184249,6	552748,7	331649,2	221099,5	683867,3	6446679,5
771971,5	192992,9	578978,6	347387,2	231591,4	710097,3	7156776,8
808168,8	202042,2	606126,6	363676,0	242450,6	737245,3	7894022,0
845633,0	211408,3	634224,8	380534,9	253689,9	765343,4	8659365,5
884408,5	221102,1	663306,4	397983,8	265322,5	794425,0	9453790,5
924541,1	231135,3	693405,8	416043,5	277362,3	824524,5	10278315,0
966078,3	241519,6	724558,7	434735,2	289823,5	855677,4	11133992,4

In this case the Performance Period of the Fund is 11 to 12 years, which is considered a mot good Performance Period of the Fund.

Table 11.26:NPV

Net present value method

	Net cash flow	Present value factor(9%)	Present value	Net Present Value
2014	261732,0081	0,917431193	240121,1083	-3511678,392
2015	278180,2579	0,841679993	234138,7576	-3277539,634
2016	295184,7686	0,77218348	227936,8019	-3049602,832
2017	312763,1515	0,708425211	221569,3016	-2828033,531
2018	330933,4686	0,649931386	215084,048	-2612949,483
2019	349714,2354	0,596267327	208523,1723	-2404426,31
2020	369124,3708	0,547034245	201923,6714	-2202502,639
2021	389183,2608	0,50186628	195317,9552	-2007184,684
2022	409910,6902	0,46042778	188734,2689	-1818450,415
2023	431326,8836	0,422410807	182197,1369	-1636253,278
2024	610380,5971	0,38753285	236542,5326	-1399710,745
2025	634038,4945	0,355534725	225422,7019	-1174288,043
2026	658524,4184	0,326178647	214796,6037	-959491,4396
2027	683867,3496	0,299246465	204644,8869	-754846,5527
2028	710097,2834	0,274538041	194948,7173	-559897,8354
2029	737245,2648	0,251869763	185689,7899	-374208,0455
2030	765343,4257	0,231073177	176850,3367	-197357,7088
2031	794425,0221	0,21199374	168413,1317	-28944,57713
2032	824524,4744	0,19448967	160361,4928	131416,9157
2033	855677,4076	0,17843089	152679,2812	284096,1969

NPV is > O so the plant is attractive

Table 11.27:IRR

Internal rate of return method IRR	Net cash flow	P.V factor (12%)	P.V factor (6%)	P.V %	Present value 6%	Net present value (12%)	Net present value (6%)
2014	261732,0	0,9	0,9	233689,3	246917,0	-3682055,2	-3668827,5
2015	278180,3	0,8	0,9	221763,6	247579,4	-3460291,6	-3421248,1
2016	295184,8	0,7	0,8	210106,7	247842,8	-3250184,9	-3173405,2
2017	312763,2	0,6	0,8	198766,6	247737,7	-3051418,3	-2925667,5
2018	330933,5	0,6	0,7	187780,5	247292,7	-2863637,7	-2678374,8
2019	349714,2	0,5	0,7	177176,1	246534,7	-2686461,6	-2431840,1
2020	369124,4	0,5	0,7	166973,1	245488,8	-2519488,5	-2186351,3
2021	389183,3	0,4	0,6	157184,6	244178,4	-2362303,9	-1942172,9
2022	409910,7	0,4	0,6	147817,9	242625,5	-2214486,0	-1699547,4
2023	431326,9	0,3	0,6	138875,7	240850,7	-2075610,3	-1458696,7
2024	610380,6	0,3	0,5	175469,8	321540,9	-1900140,5	-1137155,8
2025	634038,5	0,3	0,5	162741,9	315097,7	-1737398,6	-822058,1
2026	658524,4	0,2	0,5	150916,8	308741,9	-1586481,8	-513316,2
2027	683867,3	0,2	0,4	139932,8	302475,2	-1446549,0	-210841,0
2028	710097,3	0,2	0,4	129732,1	296298,8	-1316816,8	85457,8
2029	737245,3	0,2	0,4	120260,7	290213,9	-1196556,2	375671,7
2030	765343,4	0,1	0,4	111467,9	284221,3	-1085088,2	659893,0
2031	794425,0	0,1	0,4	103306,7	278321,9	-981781,5	938214,9
2032	824524,5	0,1	0,3	95732,9	272516,1	-886048,7	1210730,9
2033	855677,4	0,1	0,3	88705,3	266804,3	-797343,3	1477535,2

It is obvious that interest rates could be > than 9% .Somewhere between 9 and 12%. So the unit under review is attractive.

Table 11.28:ROI

	Net profit after interest and tax	Interest rate9%	SUM	ASA	ASAm
2014	130613,3481	84345,24	214958,5881	5,489597	13,34238
2015	147061,5979	92367,35	239428,9479	6,114519	15,02259
2016	164066,1086	101152,44	265218,5486	6,773132	16,75963
2017	181644,4915	110773,09	292417,5815	7,467739	18,5553
2018	199814,8086	121308,77	321123,5786	8,200831	20,41142
2019	218595,5754	132846,49	351442,0654	8,975102	22,32991
2020	238005,7108	145481,58	383487,2908	9,793471	24,31269
2021	258064,6008	159318,39	417382,9908	10,6591	26,36174
2022	278792,0302	174471,23	453263,2602	11,5754	28,47908
2023	300208,2236	191065,25	491273,4736	12,54611	30,66678
2024	479261,9371	0	479261,9371	12,23936	48,95743
2025	502919,8345	0	502919,8345	12,84353	51,37412
2026	527405,7584	0	527405,7584	13,46885	53,8754
2027	552748,6896	0	552748,6896	14,11606	56,46422
2028	578978,6234	0	578978,6234	14,78591	59,14366
2029	606126,6048	0	606126,6048	15,47922	61,91687
2030	634224,7657	0	634224,7657	16,19679	64,78714
2031	663306,3621	0	663306,3621	16,93947	67,75788
2032	693405,8144	0	693405,8144	17,70815	70,83259
2033	724558,7476	0	724558,7476	18,50373	74,01492

Table 11.29:Cost production (Scenario 4)

Production cost

	Annual general expenses for workforce(€)	Annual cost for raw materials etc(€)	Annual general expenses (€)	Depreciation and amortization of fixed	SUM
2014	238000,0	100289,0	340545,6	131118,7	809953,3
2015	246330,0	103799,1	352464,7	131118,7	833712,5
2016	254951,6	107432,1	364801,0	131118,7	858303,3
2017	263874,9	111192,2	377569,0	131118,7	883754,7
2018	273110,5	115083,9	390783,9	131118,7	910097,0
2019	282669,3	119111,9	404461,4	131118,7	937361,2
2020	292562,8	123280,8	418617,5	131118,7	965579,7
2021	302802,5	127595,6	433269,1	131118,7	994785,9
2022	313400,6	132061,5	448433,6	131118,7	1025014,2
2023	324369,6	136683,6	464128,7	131118,7	1056300,6
2024	335722,5	141467,5	480373,2	131118,7	1088681,9
2025	347472,8	146418,9	497186,3	131118,7	1122196,7
2026	359634,3	151543,6	514587,8	131118,7	1156884,4
2027	372221,5	156847,6	532598,4	131118,7	1192786,2
2028	385249,3	162337,3	551239,3	131118,7	1229944,5
2029	398733,0	168019,1	570532,7	131118,7	1268403,5
2030	412688,7	173899,7	590501,4	131118,7	1308208,4
2031	427132,8	179986,2	611168,9	131118,7	1349406,6
2032	442082,4	186285,7	632559,8	131118,7	1392046,6
2033	457555,3	192805,7	654699,4	131118,7	1436179,1

Table 11.30:Income statement

	Annual income (€)	Production cost	Depreciation and amortization of fixed	Profits before tax on
2014	1317750,0	809953,3	131118,7	376678,1
2015	1363871,3	833712,5	131118,7	399040,1
2016	1411606,7	858303,3	131118,7	422184,8
2017	1461013,0	883754,7	131118,7	446139,6
2018	1512148,4	910097,0	131118,7	470932,8
2019	1565073,6	937361,2	131118,7	496593,7
2020	1619851,2	965579,7	131118,7	523152,8
2021	1676546,0	994785,9	131118,7	550641,5
2022	1735225,1	1025014,2	131118,7	579092,2
2023	1795958,0	1056300,6	131118,7	608538,8
2024	1858816,5	1088681,9	131118,7	639015,9
2025	1923875,1	1122196,7	131118,7	670559,8
2026	1991210,7	1156884,4	131118,7	703207,7
2027	2060903,1	1192786,2	131118,7	736998,3
2028	2133034,7	1229944,5	131118,7	771971,5
2029	2207690,9	1268403,5	131118,7	808168,8
2030	2284960,1	1308208,4	131118,7	845633,0
2031	2364933,7	1349406,6	131118,7	884408,5
2032	2447706,4	1392046,6	131118,7	924541,1
2033	2533376,1	1436179,1	131118,7	966078,3

Profits after interest	Tax(25%)	Net profit after interest and tax	Dividend shares	Reserve	Net cash flow	Cumulative net cash flow
376678,1	94169,5	282508,5	169505,1	113003,4	413627,2	236354,7
399040,1	99760,0	299280,1	179568,0	119712,0	430398,7	666753,4
422184,8	105546,2	316638,6	189983,2	126655,4	447757,3	1114510,7
446139,6	111534,9	334604,7	200762,8	133841,9	465723,3	1580234,0
470932,8	117733,2	353199,6	211919,7	141279,8	484318,2	2064552,2
496593,7	124148,4	372445,3	223467,2	148978,1	503564,0	2568116,2
523152,8	130788,2	392364,6	235418,8	156945,8	523483,3	3091599,5
550641,5	137660,4	412981,1	247788,7	165192,4	544099,8	3635699,2
579092,2	144773,1	434319,2	260591,5	173727,7	565437,8	4201137,0
608538,8	152134,7	456404,1	273842,4	182561,6	587522,7	4788659,8
639015,9	159754,0	479261,9	287557,2	191704,8	610380,6	5399040,4
670559,8	167639,9	502919,8	301751,9	201167,9	634038,5	6033078,9
703207,7	175801,9	527405,8	316443,5	210962,3	658524,4	6691603,3
736998,3	184249,6	552748,7	331649,2	221099,5	683867,3	7375470,6
771971,5	192992,9	578978,6	347387,2	231591,4	710097,3	8085567,9
808168,8	202042,2	606126,6	363676,0	242450,6	737245,3	8822813,2
845633,0	211408,3	634224,8	380534,9	253689,9	765343,4	9588156,6
884408,5	221102,1	663306,4	397983,8	265322,5	794425,0	10382581,6
924541,1	231135,3	693405,8	416043,5	277362,3	824524,5	11207106,1
966078,3	241519,6	724558,7	434735,2	289823,5	855677,4	12062783,5

In this case the Performance Period of the Fund is 8 to 9 years, which is considered a good Performance Period of the Fund.

Table 11.31:ROI

Simple method performance factor (ASA)

	Net profit after interest and tax	Interest rate9%	SUM	ASA	ASAm
2014	130613,3481	84345,24	214958,5881	5,489597	5,559324
2015	147061,5979	92367,35	239428,9479	6,114519	6,259414
2016	164066,1086	101152,44	265218,5486	6,773132	6,983181
2017	181644,4915	110773,09	292417,5815	7,467739	7,731373
2018	199814,8086	121308,77	321123,5786	8,200831	8,50476
2019	218595,5754	132846,49	351442,0654	8,975102	9,30413
2020	238005,7108	145481,58	383487,2908	9,793471	10,13029
2021	258064,6008	159318,39	417382,9908	10,6591	10,98406
2022	278792,0302	174471,23	453263,2602	11,5754	11,86628
2023	300208,2236	191065,25	491273,4736	12,54611	12,77783
2024	479261,9371	0	479261,9371	12,23936	20,39893
2025	502919,8345	0	502919,8345	12,84353	21,40588
2026	527405,7584	0	527405,7584	13,46885	22,44808
2027	552748,6896	0	552748,6896	14,11606	23,52676
2028	578978,6234	0	578978,6234	14,78591	24,64319
2029	606126,6048	0	606126,6048	15,47922	25,7987
2030	634224,7657	0	634224,7657	16,19679	26,99464
2031	663306,3621	0	663306,3621	16,93947	28,23245
2032	693405,8144	0	693405,8144	17,70815	29,51358
2033	724558,7476	0	724558,7476	18,50373	30,83955

All scenarios are acceptable but we will choose the second one because it’s the one that will return us our budget in the least years.(7-8)

10.9 Conclusions

- ✓ The Period of return on capital is calculated at approximately seven (7) years, which is attractive in terms of investment.
- ✓ The method of net present value and internal rate of return showed that the plant is an attractive investment.
- ✓ The proceeds of this investment have the particularity of being steadily, and can be calculated even from the pre-investment phase of the investment program with great security.
- ✓ This investment has a low risk and relatively low performance and fit Investors who do not wish to take a big risk, but one wish to have a fixed income for quite a long time.
- ✓ The investment is useful in terms of sound national economic growth.
- ✓ The investment is recommended

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