THE SIXTH FRAMEWORK PROGRAMME
for Research, Technological
Development and Demonstration

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ALF-CEMIND:
Supporting the use of alternative fuels in the cement industry

Specific Support Action
Thematic Promotion and Dissemination

FINAL PUBLISHABLE REPORT

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Project coordinator name: **Niki Komioti**

Project coordinator organization name: **EXERGIA S.A.**

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1. PROJECT EXECUTION

1.1. Introduction

Project ALF-CEMIND was a specific support action within the European Commission Sixth Framework Programme for research, technological development and demonstration (RTD). It was an 18 month duration project that started on July 2006 and concerned the implementation of waste exploitation technical solutions under the polygeneration concept in cement industry.

1.2. Summary of project objectives

The overall objective of this specific support action is to disseminate technical knowledge and experience from the implementation of waste exploitation technical solutions, with the overall objective to assist the take-off of polygeneration in the cement industry leading to energy, environmental, societal and economic benefits. The targeted sectors of the cement industry were that of Greece, Romania, Bulgaria, Poland, Cyprus and Turkey where the potential for improvement and better utilisation of the existing infrastructure in the cement industry is significant.

During the 18-month project period, the key priorities of the project activities have been focused on the following:

- To increase knowledge of polygeneration with the use of alternative fuels in the cement industry of the participating countries;
- To transfer expertise in design and engineering, and practical experience from application, from the technology developers to the end-users;
- To increase commercial availability of the results of EU research projects;
- To prove the applicability of the technology to a variety of implementation environments, and to understand its limitations;
- To produce and disseminate information on technical and economic feasibility of the polygeneration with the use of alternative fuels in the cement industry.

The Consortium has accomplished all the tasks according to the work programme, in time and with good quality results. The project results are presented in the following chapters.

1.3. Partnership

A well-established consortium has been formulated, comprising European organisations, namely EXERGIA, Energy and Environment Consultants (GR), Sofia Energy Centre – SEC (BG), Tractebel Project-Managers, Engineers & Consultants S.A. (RO), Van Heekeren & Frima Management Consultants BV (NL), Cyprus Institute of Energy – CIE (CY), Merkat, Energy-Environment-Industry Manufacturing, Marketing, Consulting and Representation Inc (TR).

Activities in Poland have been carried out by the Instytut Paliw I Energii Odnawialnej (IPiEO) through sub-contracting agreement.

1.4. Summary of work package performance

The ALF-CEMIND activities were performed organised in the following four work-packages:

WP 1: Project management and coordination

WP 2: Technology transfer

WP 3: Preparation of pre-feasibility studies.

WP 4: Consolidation of results and dissemination

The work carried out by the Consortium within the project duration can be outlined in the following:

- Project co-ordination and meetings.
- Technology transfer / Organisation of training workshops in all of the countries involved.
- Technology transfer / Study tour of cement plant operators in two cement plants and one sewage treatment plant in the Netherlands.
- Prefeasibility studies regarding polygeneration with the use of alternative fuels will be carried out, preferably one in each of the participating countries.
- Dissemination of the results / Development and maintenance of the project website.
- Dissemination of the results / Design and publication of an information brochure.
- Dissemination of the results / Elaboration and development of a technology implementation guide.
- Dissemination of the results / Organisation of the final project workshop that have been organised in Athens at the end of the project.

During the reported period the Consortium has accomplished all the tasks according to the Work Programme, in time and with good quality results. Emphasis has been put on the technology transfer activities.

A description of the activities carried-out within each work package follows:

WP1 – Project management and coordination

EXERGIA has the role of the overall coordinator, being the main contractor of the project.

The members of the Consultant have met in kick-off held in Athens and in two co-ordination meetings in order to discuss important matters aiming to manage and organize the project activities.

For the effective carrying out of the work, a frequent communication between the members of the project team was established, mainly by means of regular meetings and via phone and e-mail communication.

For disseminating the project results not only in the 6 participating countries but widely in Europe, the European Cement Industry Association (CEMBUREAU) participated in ALF-CEMIND project as sub-contractor. Finally, two more subcontractors were assigned in the project, KHD (DE) and NTUA (GR) for the technology transfer activities. The above mentioned collaborations were foreseen in the project work programme.

Further to the above, communication between the Consortium and the SCs in the participating countries has been established on the purposes of obtaining guidelines for the handling of important issues for the project execution.

The following tasks carried out for the adequate management of the project:

- Fostering and maintaining good communications and relationships amongst all partners and with the Commission (including reporting).
- Co-ordination and integration of partners activities to ensure synergies.
- Managing the financial and business aspects of the project.
- Plan for using and disseminating the knowledge.

WP2 – Technology transfer

The main activities in this work package were the **review of the cement industry** in relation with exploitation of AF and ARM, the **organisation of training workshops** on the use of *"Alternative fuels and raw materials in cement industry"* focusing mainly on technology issue also in each of the countries involved and the **organization of a study tour**.

The *Review of cement industry in the countries involved* consisted a preparatory activity for the initiation of the project activities. Therefore, the work in WP2 started with the elaboration of a brief report on the cement industry which presented more or less the following:

- Country Structure
- Concise description of cement industry & stakeholders
- Status quo alternative fuels
- Target site(s)
- Basic analysis of opportunities for Alternative Fuels and raw materials
- Description of technology employed (type of kiln, milling installation)
- Potential for alternative fuels and raw materials
- Key decision factors
- Prospects and Future Developments
- Executive summary
- References

The *workshops in each country* (Romania, Bulgaria, Greece, Turkey, Cyprus and Poland) were attended by at least 40 people and provided a forum and an impetus to the understanding of the diverse range of aspects in reference with the waste utilization in cement industry. The EU Policy, the local energy requirements, the regulatory issues related to the exploitation of several waste streams by the cement industry along with examples of their successful use were discussed. Companies were given the chance to introduce their technologies and discuss the key characteristics of the significantly expanding alternative fuels and raw materials technology.

KHD had been invited as technology provider to participate in the workshops and present polygeneration with the use of alternative fuels to these workshops, as the technology applies to cement industry. Cement plant operators and other stakeholders relevant to cement industry attended the workshops.

WP 3: Preparation of pre-feasibility studies

The Consortium had undertaken the elaboration of pre-feasibility studies regarding polygeneration with the use of alternative fuels. Initially it was planned at least one pre-feasibility to be carried out in each of the participating countries (Greece, Bulgaria, Romania, Cyprus, Turkey and Poland). The prefeasibility studies were to be carried out by the respective project partners in each country and to address investments in the cement plants with real application potential which has been identified in previous project activities.

However, as it was mentioned before the preparation of the pre-feasibility studies in some of the participating countries was not an easy to implement task. The project partners from the participating countries encountered difficulties approaching their cement industry representatives.

In general, as it was mentioned previously, the Cement Industry in most of the participating countries is rapidly advanced concerning the use of alternative fuels and raw materials during the last 5 years. During the project period almost all of the cement plants in the participating countries were using at least one type of alternative fuel or raw material.

After the discussions arisen in project meetings and in the national workshops with the presence of the representatives of the Cement Industry, it is considered that major attention should be given regarding these pre-feasibility studies to the identification / analysis of the various waste streams. Since most of the cement plants in the other participating countries have already incorporated alternative fuels and raw materials into the production process (although a small portion), they face problems in finding and collecting the various types of waste in the regions near the cement plants in order to substitute bigger quantities of fuels and raw materials. Therefore, the Consortium concluded that key priority of the project activities in this task should be the market assessment of alternative waste streams used by the cement industry rather than to put emphasis on the formulation of a typical model for the evaluation of such an investment. To this end, the Consortium members adjusted their work to present to their national cement industry practical knowledge and information not only on the feasibility of the investments on alternative fuels but mainly on the accessibility and the exploitation of the waste streams potential in each participating country.

Considering the above, project partners had to decide to perform either pre-feasibility studies to one or more cement plants as they described to the WP3 of the project work programme or to elaborate a study on the logistics of waste taking into consideration the comments by the EC Officer.

WP 4: Consolidation of results and dissemination

The work package activities were the following:

- Design and development of the project WEB and STS sites
- Design and publication of an information brochure
- Design and publication of the technology implementation guide
- Networking
- Final workshop

The establishment of networking at national and international level supported the transfer of best-practice methods on promoting and financing this polygeneration technology in the cement industry.

The cooperation with CEMBUREAU was one of the most important milestones of the project. They supported substantially the project with their presence in all national workshops and disseminating project information material.

The Consortium identified the project stakeholders in all participating countries and established SCs to discuss critical project issues and present the project results and deliverables.

1.5. Results – Main Deliverables

The main Deliverables of the project are presented more analytically in the following paragraphs.

D12: Organization of the study tour

A study tour was organized in two cement plants, Enci and Lixhe (experienced in alternative fuels and raw materials) and one sewage sludge treatment plant, Waterschapsbedrijf Limburg in the borders of Belgium and the Netherlands on the 29th and 30th of August 2007. Attendees viewed plant facilities and were also informed about the latest developments for codification of EU laws relating to environmental issues and the problems of ensuring a regular supply of alternative fuels for the European cement plants.

Photos 1 and 2: ALF-CEMIND study tour in ENCI and LIXHE cement industries

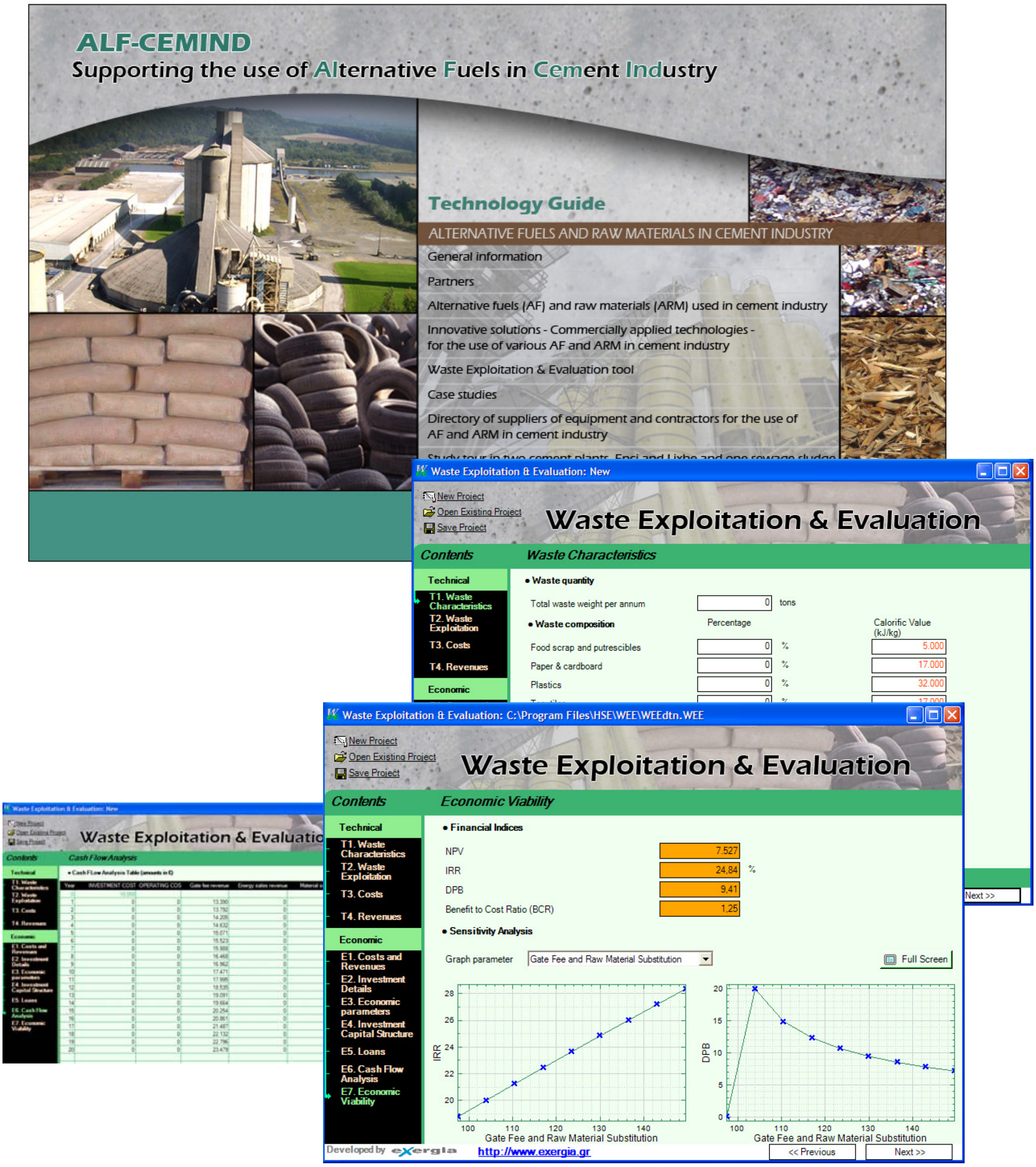
D13: Design and publication of the Technology implementation guide

Technology-related information, as well as data regarding the applicability of the technology in cement plants were used for the development of a guide in CDs.

Main parts of the **ALF-CEMIND technology guide** are:

- Main page
- General information on the project
- Partners
- Alternative fuels (AF) and raw materials (ARM) used in cement industry. Study report prepared by EXERGIA
- Innovative solutions – Commercially applied technologies - for the use of various AF and ARM in cement industry. Presentation of technologies. Information gathered by EXERGIA after surveys to technology providers internationally.
- Waste exploitation & Evaluation tool. Development of a tool by EXERGIA in visual basic environment.
- Case studies
- Directory of suppliers of equipment and contractors for the use of AF and ARM in cement industry. Classification of information gathered by EXERGIA through serveys. Presentation of technology providers and information on their activities and services.
- Study tour in two cement plants, Enci and Lixhe and one sewage sludge treatment plant, Waterschapsbedrijf Limburg

In the screenshot below you can see the main page of the technology guide. The links on the right open the various parts of the guide.



Deliverable: Review of cement industry in the countries involved

Greece

The Greek Cement Industry consists of 8 cement plants with an installed capacity of approximately 18 million tons per annum, owned by 3 companies: HERACLES G.C.Co Group of Companies, TITAN Cement Company S.A. and HALYPS Cement. The annual increase in cement production between 1995 and 2004 was about 8.5%, while a steady state is observed, for the years 2003 and 2004. In the future, is expected a slight annual increase (approximately 3%) until 2010. The annual cement production in Greece for 2004 was approximately 15.6 million tons.

Regarding the use of alternative fuels, Greece is ranked among the countries with very low substitution rates. Although there are the suitable circumstances, currently their management is disposal to landfills than to use them as thermal source of energy. In 2006, cement plants utilized only about 1% of alternative fuels in their production process which is marginal relative to other European countries. Nevertheless, the future seems promising since there are many types of waste available near the regions where most of the cement plants are located. Waste streams that will be used in the coming years are sewage sludge from Psitalia, RDF, used tyres and sludge from refineries.

Bulgaria

In Bulgaria during the last few years with the transition of Bulgarian economy to market principles, all Bulgarian cement production capacities were bought by three leading European cement companies: Italcementi Group owns “Devnya Cement” SC and Vulkan Cement SC; TITAN Cement – Greece owns Zlatna Panega Cement; Holcim Group owns: Holcim Bulgaria SC (former Beloizvorski Cement) and Plevenski Cement SC. The annual cement production in Bulgaria was almost 3 million tons for 2004.

All of these leading companies after the privatization have invested in increasing of plants’ quality and environmental protection. At present the Bulgarian Cement Industry almost does not use wastes as alternative fuels and as raw materials. It should be noted, however, that all five cement plants are preparing for wide use of wastes as follows: “Devnya Cement” SC uses copper slag (about 45,000 t) and ash from TPPs (about 250,000 t) in annual basis. Forthcoming is the construction of a new furnace for clinker, complying with all requirements for environmental protection and designed to utilize alternative fuels. “Vulkan Cement” is not foreseen to use alternative fuels in the near future. “Zlatna Panega” – TITAN Cement made an experiment in 2003 and 2004 to use car tyres (up to 8.8%) as alternative fuels, but at present alternative fuels are not used. A fully automated line for used tyres has been developed in Holcim “Bulgaria” SC. From September 2007 Holcim Bulgaria is also using animal meal and at the end of 2007 an installation was also finalized for cutting, dozing and transport of solid waste – different types of plastics, paper, textile and others. “Plevenski Cement” SC also experimented with utilization of car tires but at present is not using the waste.

Romania

In Romania, there are only three cement producers, all being part of international groups: Lafarge, Holcim and Heidelberg. For this reason, they are all very well informed about the use of alternative fuels and raw materials in the cement production process, each cement company applied on the local market all the know-how available within the group they belong to.

Nowadays, the most used alternative fuels are used tyres, 12 000 tons have been valorised through coincineration in 2004. In the same way, potential for alternative raw materials is quite high. Among them, we can distinguish: slag furnace; fly ash from thermal power stations; foundry sand.

The annual cement production in Romania was approximately 7 million tons for 2005. For the next five years, it is estimated that the cement production will grow up with, at least, 10% per year.

Cyprus

There are two cement production sites in Cyprus, Cyprus Cement Company and Vassilico Cement Company. Both are using ARM´s but only Vassilicos uses AFs. Today Vassilicos Cement Company is using 6% AFs but its target is to go for new lines by 2010 which will be utilizing alternative fuels that would result in replacing at least 35% of the conventional fuels normally required (pet-coke). About 41400 tns of pet-coke can be saved from the use of biomass (as alternative fuel).

The only ARMs that is produced in Cyprus and is consumed for the production of cement is high quality limestone from the cement plants own quarry. All other ARMs are imported, pozzolanic matter and slag.

The total cement production in Cyprus is estimated about 1.7X106 tns / yr from the two cement production sites.

Turkey

In the Turkish Cement Sector, there are 41 integrated and 19 grinding plants of which one belongs to the public sector. About 30 percent of the plants is owned by the international conglomerates. This sector includes 18 companies in “Top 500” and 25 companies in “Top 1000” among the largest companies of Turkey.

Turkey possesses one of the highest installed cement production capacities in the Middle and Europe. Based on 2006 figures, cement and clinker production capacities are 70.7 and 42.6 million tons, respectively.

The main waste derived fuels available in Turkey that can potentially be used in cement plants are: Paper waste; Textile waste; Carpet waste; Plastic waste; Rubber waste; Waste tires; Waste wood; Water Treatment Sludge; Sewage sludge; Animal meal; Asphalt; Petrochemical and Chemical waste; Tar; Acid sludge; Waste oil; Varnish residues; Waste solvents; Waste paints; Distillation residues; Wax suspensions; Asphalt sludge and oil sludge.

The most likely candidate alternative raw materials for the Turkish Cement sector are;

- Blast furnace, steel furnace slag, fly ash from the thermal power plants;
- Additives such as trass and limestone,
- Chemical additives which will increase the strength of the cement.

Poland

Cement industry in Poland consists of 11 cement plants working in complete production cycle, 1 grinding plant and 1 aluminous cement plant. Cement branch is privatized in 100%. The modern methods in management, process control, production concentration as well as economic efficiency and environment protection influenced on high level of the cement industry in Poland, which is counted among the leading in Europe.

In 2004 almost 10% of heat used in cement manufacturing process came from renewable sources of energy. The share of heat from alternative fuels in cement industry from 1997 and onwards in continuously increasing, reaching almost 14% in 2005.

D14 – D20: Seven studies and reports (pre-feasibility, logistics of waste, policy framework) proving the potential of poly-generation investments in cement industry.

In the following, a summary of the study performed along with the main points of their methodology and their work results is presented:

D14: Pre-feasibility study report / Greece

1. INTRODUCTION

The work was organised in two parts. The first is about the international experience in the exploitation of Alternative fuels and Alternative raw materials by the cement industry and includes information on types, characteristics, technology required, best practice and examples of their implementation. The second part consists of a review of the sources and the potential of AF and ARM as they apply to Greece as well as of a detail techno-economic assessment of the use of AF in all cement plants in Greece. It should be mentioned that in the second part of the study, EXERGIA was cooperated with experts from the NTUA and more specifically with the Prof. Ev. Kapetanios and Prof. N. Markatos.

Cement manufacturing can safely use waste-derived fuels and alternative raw materials since:

- the cement kiln sustains high temperatures;
- the raw material and gas remain in the kiln over a relatively long period;
- the process is enhanced by an alkaline environment that tends to scrub combustion gases;
- the process incorporates mineral components into the clinker.

The technologies have been introduced for more than fifteen years and are now well established. Waste consumption nowadays represents approximately 17% of the industry's fuel mix and is used in 25 EU Member States. Innovative technologies allow some EU companies to recover a substantial amount of waste-derived fuels which replace fossil fuels up to a level of 100%.

The range of fuels is extremely wide. Traditional kiln fuels are gas, oil or coal. Materials like RDF, used oils, animal meal, used tyres and sewage sludge are often proposed as alternative fuels for the cement industry.

The major alternative fuels used in Europe for the production of cement are presented in Table 1.**Error! Reference source not found.**

Waste streams (Year 2004)	**Hazardous**	**Non-hazardous**	**Total (1000 tonnes)**
Animal meal, fats	0	1285074	1285074
Rubber, tyres	0	810320	810320
RDF	1554	734296	735850
Solvents and related waste	517125	145465	662590
Oils	313489	196383	509872
Plastics	0	464199	464199
Solid alternative fuels (impregnated saw dust)	149916	305558	455474
Wood, paper, cardboard	1077	302138	303215
Municipal sewage sludge	0	264489	264489
Industrial sludge	49597	197720	247317
Others	0	212380	212380
Coal, carbon waste	7489	137013	144502
Agricultural waste	0	69058	69058
Textiles	0	8660	8660

Table 1: Waste streams used in the European cement industry

Apart from the alternative fuels mentioned before, a number of ARM are used in the cement production process. Alternative raw materials come from other processes as in iron making and aluminium processing as by-products or excess materials. The chemical composition of these raw by-products can be classified as hazardous or non-hazardous.

Co-processing of alternative raw materials in the cement production will provide with less demand of the primary raw materials (e.g. limestone, clay, etc), thus decreasing the requirements for quarrying traditional primary materials.

Alternative raw materials that are mostly used as substitutes in the production of cement include the following:

- Iron and steel slag;
- Fly ash;
- Foundry sand;
- Other including municipal incinerator ash, calcium fluoride, mill scale, etc.

The Greek Cement Industry (GCI) is one of the most important components of the Greek Industry. The eight cement plants, although distributed all over the country, are intentionally close to the largest urban areas (Attica, Thessalonica, Patra, Volos/Larissa). The annual production of the Greek Cement industry, approximately 18 million tones clinker and cement, does not only aim to satisfy the needs of the interior market, but a large amount of its production is exported to many other countries all over the world.

Until now we have seen that the amount of the used wastes as AF in Greece and especially in Cement Industry is very low (<1%). Although the available sources of wastes that exist in Greece are in very attractive quantities, their main disposal “way” is the landfilling. One of the most promising ways of their disposal could be their use as AF in Cement Industry.

The waste disposal in national level varies from region to region. The available AF existing today, as well as potential sources of AF of sufficient quantity and appropriate quality characteristics in order to be of satisfactory use and replace CF, are as follows:

- RDF
- Sewage sludge
- Used tyres
- Glycerol (waste from Biodiesel production)
- Used Mineral Oils and lubricants
- Sludge from refineries (Industrial slag)
- Agricultural and organic waste
- Animal meal, bone meal and animal-fat waste

Refuse Derived Fuel (RDF)

In 2005 the annual production of RDF from the Mechanical Recycling Plant at Ano Liossia (Attica Region) was 41,000 tons. In 2006 it was 60,000 tons. It is expected that in 2007 the annual production will be over the 80,000 tons of RDF *[these data were obtained from the Association of Communities and Municipalities of Attica Region (A.C.M.A.R) and the Ministry of Environment].*

In 2007, A.C.M.A.R and HERACLES G.C.Co Group of Companies signed a long term contract for incineration of about 30,000 tons/year (if RDF satisfies user specifications) in the cement plant of HERACLES in Mylaki (Evoia). The rest of RDF production (~50,000 tons/year) could be available and used as AF by any other customers.

Until now there has been no transportation - incineration of RDF at Mylaki’s plant, as the necessary technical conversions and the appropriate test period for the use of RDF have not taken place. Also the local community reacts very vigorously against the use of RDF at Mylaki’s plant.

The future regional plans for Attica aim of constructing in West Attica two more mechanical recycling plants, of total capacity 2,000 tons/day RDF, and two other plants, one in NE and one in SE Attica respectively, of total capacity 150 tons/day RDF. Should these plans proceed without any problems (e.g. reactions of local communities, regulatory difficulties etc.) then they will start production just after 2011.

Also the Plant of Mechanical Recycling of municipal wastes in the region of Hania (Crete), selected, packed and sent to Athens approximately 40 tons/day. Until the end of 2007 it is expected to recycle 6,000 tons of paper and 1,000 tons of plastic. Paper and plastic could be used as AF by the cement industry.

The European Community asks every member state to proceed to recycling of municipal solids, and sets relevant deadlines for recycling in all countries.

Sewage Sludge (SS)

The only sewage plant in Greece that produces sludge, which under appropriate ‘drying’ processing could become a favourable alternative fuel is in Psitalia inland (in the region of Attica). The daily production of sewage sludge is more than 750 tons. In Psitalia there is in operation the plant for Sewage Sludge drying.

The burning of Psitalia’s sewage sludge from Kamari’s plant (TITAN), is 100 tons/day (25-30,000 tons/year), and is expected to produce 350-440 TJ/year.

In Thessaloniki’s sewage plant there is no design for further disposal of the produced sludge. Until today there is no relevant plan for sludge’s drying. However it remains a potential source of “stored” energy which is estimated at ~500 TJ/year in “dry” mode. Similarly for Patra’s it is ~200 TJ/year and for Volos and Larissa about 180 TJ/year.

Used tyres (UT)

In 2005, more than 24,000 tons of scrap tyres were selected in Greece. From the above quantity the 20.63% was reused as tyre-derived fuel (TDF) in TITAN, the 38.42% was recycled into new products, the 6.89% is metals from processing production and the 7.79% is fibers and waste disposals of processing production. Rest of the 26.28% is stored in various tyre stockpiles.

Every year in Greece, there are imported 47-50,000 tons of tyres. The 20% per weight of imported tyres comes by the imported used vehicles [ECOELASTIKA S.A.].

Tyres can be used as fuel either in shredded form - known as tyre derived fuel (TDF) - in whole, depending on the type of combustion device used. Scrap tyres are typically used as a supplement to traditional fuels, such as coal or wood. Generally, tyres need to be reduced in size to fit in most combustion units. Besides size reduction, use of TDF may require additional physical processing, such as de-wiring.

There are several advantages of using tyres as fuel:

- Tyres produce the same amount of energy as oil and 25% more energy than coal
- The ash residues from TDF may contain a lower heavy metals content than some coals
- Tyres result in lower NOx emissions when compared to many U.S. coals, particularly the high-sulfur ones.

Although the use of TDF as substitute of conventional fuels in cement industry is very beneficial, however, similarly waste oils, TDF are the source of important pollution, due to the emissions from their burning. The emissions from TDF's burning must overcome the stricter European and Greek legislation for emissions and the local communities' reactions close to the cement plant.

Waste of biodiesel production (glycerol)

The use of biofuels is an effective way of reducing the gas emissions responsible for the greenhouse effect and for addressing global climate change. Production of these alternative fuels is creating new forecasts for employment in agriculture and forestry, investment in new technology and for the development of cleaner, more efficient industries using natural resources. From a technical standpoint, existing fuel installations can be modified to use biofuels.

The current situation in Greece for the production of biodiesel, is summarized as follows. The first plant producing biodiesel was in Kilkis (December of 2005) run by Hellenic Petroleum with annual capacity of 45,000 tons. The next plants were, one in Thessaloniki (July 2006) with annual capacity of 25,000 tons run by VERT OIL S.A., one in Patra's (July 2006) with annual capacity of 45,000 tons run by PAVLOS N. PETAS S.A., one in Fthiotida (November 2006) with annual capacity of 200,000 tons run by AGROINVEST S.A. and one in Volos (December of 2006) run by ELIN with annual capacity of 80,000 tons.

Additionally, from currently selected information, eight other production plants are at the first stages of design and construction with estimated annual production capacities of: four of 5,000 tons, two of 11,000 tons, one of 22,000 tons and one of 100,000 tons with estimated date of production at the end of 2007. Apart from these, many other companies all over Greece have expressed their interest for the construction of plants for biodiesel production of low, medium and large capacity.

From the raw materials that are used for the production of biodiesel the 70-80% are imported oils (soya oil, grape seed oil etc.), and 10-20% local oils (sunflower and cottonseed oil, kitchen oil etc.).

Experts agree that Greece is in a position to produce excellent and competitively priced biofuels. Biodiesel is produced by esterification (converting to esters) from vegetable oils (and animal oils) and methanol, with glycerol as a by-product which can be used in cement industry and bioethanol produced from raw materials rich in hydrocarbons. Greece has a large number of crops that can be used for the production of biodiesel. Sunflower and cottonseed oil are expected to play an important role along with grape seed oil, which is considered highly suitable. In addition, tobacco oil and tomato oil are very promising raw material alternatives.

Mineral Oils (MO)

According to Greek legislation (L.2939/2001) an alternative system for the collection of used mineral oils is in operation. According to information obtained from the Greek Ministry of Environment, every year in Greece are consumed approximately 140,000 tons of mineral oils. Half of them are used in vehicles, 20% for industrial use and the rest of 30% for the needs of the ship fleet in Greece. 50% of the mineral oils are consumed in Attica, 15% in Thessaloniki and the rest of 35% in the rest of Greece. The total selected quantity of MO is estimated to 85,000 tons, approximately. From the above quantity, in the year 2004, only 30,000 tons were selected legally and most was regenerated. The rest of MO was disposed uncontrolled to the local environmental or was selected illegally and used as AF. According to national legislation, the 70% of the used MO (60,000 tons) must be selected and from this quantity the 80% (per weight) must be regenerated (48,000 tons).

The waste mineral oil is utilized energetically in cement works. Integrated assessment takes into account that it thus substitutes coal as a fuel in cement works. Recycled waste oil must comply with the specifications applicable for high-grade engine oil. The main energy source of GCI is pet-coke. Usually Fuel Oil (Heavy fuel oil) is used to help the process of pet-coke's burning. The use of FO can be replaced by the MO as substitution fuel, and in some cases it is used as main fuel of the plant. This method is very popular in many countries in Europe. The burning of MO in cement industry solves the problem of MO disposal and achieves significant economy as the MO have much lower price than FO and are of similar calorific value.

The substitution of FO by MO in cement industry is estimated that will decrease the energy consumption and greenhouse gas emissions significantly. However, waste oils have been and still are the source of important pollution. Waste oils are clearly hazardous waste and usually contain quite stable aromatic organic compounds, some heavy metals and can pollute by soluble contaminants like PCBs which are generated by their burning. The emissions from MO's burning can be of great concern to the local population close to the cement plant.

Sludge from refineries (Industrial Slag)

The only regions with refineries in Greece are in Attica and Thessaloniki. A large amount of the waste of Attica refineries is already used by POLYECO S.A., a recycling company, which is mixing it with sawdust and supply it to Kamari's plant (TITAN). Recent year's production was: 6,000 tons in 2004, 10,500 tons in 2005 and 10,000 tons in 2006.

There isn't any information about the thermal development of Thessaloniki's refineries waste. Consequently this amount of waste is an easy stock for further development. It is estimated that refineries waste production is about 2,000 tons/ year mixed with sawdust.

Agriculture and organic waste

Although there is a considerable amount of Agriculture and organic waste, especially close to the regions of Thessaly, Patra and Thessaloniki, there isn't any information about the thermal utilization of Agriculture and organic waste in Greece, except for their use from the local communities as fuel. Consequently, this amount of waste (which must satisfy user standards) is a promising source for further thermal utilization in the cement industry *[Source: CERS]*.

Animal meal, bone meal and animal fat waste

The collection and disposal of the produced animal waste constitutes a major environmental problem for which there hasn't been until now a radical mean of confrontation. Although there is a considerable amount of wastes from animal meal, bone meal and animal fat, there isn't any information about the thermal utilization at national level. Consequently, these amounts of waste (which must satisfy user standards) is a promising source for further thermal utilization in the cement industry and a suitable technique for solving or restrain the environmental problem, especially to the local community where this waste must alternatively disposed or landfilled. Something that must be taken into consideration is the storage and transportation of this kind of waste to the cement plants. This means that an appropriate system must be developed and the cement industry must design the technical conversion of plants for their burning. In any case, burning of animal waste in cement kiln is more profitable than burning it in new incineration plants that must be constructed especially for these types of waste.

An approximate estimation of the available quantities of animal waste in Greece is ~3,500 tons/year in Thessaly, ~8,000 tons/year in Thessaloniki, 12,000 tons/year in Attica and 3,500 tons/year in Patra.

2. FUTURE PLANS AND FORECASTS FOR WASTE EXPLOITATION IN GREEK CEMENT INDUSTRY

The distribution of alternative fuels (wastes) in Greece is based on a thorough investigation and communication with all the participants that are interested in this kind of work. This means that primary wastes are found from various sources (CERS, Ministries of Environment & Agriculture, ERA, Various companies or organisations – ACMAR - etc.) that are involved with the collection of wastes, national bibliography & collaboration with Greek Cement Industries) and are distributed in such a way as to have the optimum benefit taking into consideration:

- the future plans of each cement industry,
- the availability of each source of waste close to the location of each plant,
- the distance of sources of waste to each plant,
- barriers such as local communities reaction for the possible passage of waste through them, and
- the available unexploited waste that exist in various sources in the Greek region (as landfills, refineries, sewage sludge treatment plants, etc.) that, due to the stricter legislation, must be managed and operated in a suitable way.

The distance that a waste carrier must cover from the sources of wastes to the plant (km) and back is evaluated taking into consideration the distance from each plant to the closest available source of wastes (existing and possible future ones) such as landfills, refineries, sewage sludge treatment plants, biodiesel production plants, companies involved with wastes collection, etc.

TYPE OF FUEL	ATTIKI & ISLANDS	THES/NIKI	PATRA	VOLOS & LARISSA	TOTAL
Used Tyres (UT)	9000	3750		2250	15000
Industrial Slag (ISL)	10000	5000			15000
Glycerol	3850	2750	4400		11000
RDF	80000				80000

Sewage Sludge (SS)	90000				90000
Animal Meal (AM)					0
Used Oil (UO)		500		1000	1500
Biomass					0
Mineral Oil (MO)	12350	4750		1900	19000

Table 2: Available Wastes (tons) that can be used as AF in 2008 – 2012

TYPE OF FUEL	ATTIKI & ISLANDS	THES/NIK I	PATRA	VOLOS & LARISSA	TOTAL
Used Tyres (UT)	9900	8100		12000	30000
Industrial Slag (ISL)	15000	7000			22000
Glycerol	9240	7560		11200	28000
RDF	280000				280000
Sewage Sludge (SS)	90000	37000	12000	13000	152000
Animal Meal (AM)	5250	4500		5250	15000
Used Oil (UO)	1400	600			2000
Biomass	4800	11200		16000	32000
Mineral Oil (MO)	17080	8120		2800	28000

Table 3: Available Wastes (tons) that can be used as AF in 2012 – 2016

	UT	ISL	GLYCEROL	RDF	SS	AM	UO	BIOMASS	MO
PLANT 1	5000	10000	1000	25000	25000		1000		2000
PLANT 2		5000	2600				500		3000
PLANT 3	4000		1000						3000
PLANT 4	6000		4400						4000
PLANT 5				36000					
PLANT 6			1000	10000					2000
PLANT 7			1000	9000					1500
SUM TOTAL	**15000**	**15000**	**11000**	**80000**	**25000**		**1500**		**15500**

Table 4: Distribution of Wastes that can be used as AF in Greece in 2008 – 2012 (tons)

	UT	ISL	GLYCEROL	RDF	SS	AM	UO	BIOMASS	MO
PLANT 1	8000	15000		80000	50000		1400		3000
PLANT 2	7000	7000	6000		37000	800	600	11200	4000
PLANT 3	8000		6000	30000	12000	700		1800	3000
PLANT 4	5000		11000		13000	1500		16000	5000
PLANT 5				90000	10000				
PLANT 6			3000	60000	20000	500		1500	4000
PLANT 7	2000		2000	20000	10000	800		1500	2000
SUM TOTAL	**30000**	**22000**	**28000**	**280000**	**152000**	**4300**	**2000**	**32000**	**21000**

Table 5: Distribution of Wastes that can be used as AF in Greece in 2012 – 2016 (tons)

CEMENT CAPACITY PLANTS	**PLANT 1**	**PLANT 2**	**PLANT 3**	**PLANT 4**	**PLANT 5**	**PLANT 6**	**PLANT 7**
TYPE OF WASTE	**DISTANCE-(VISA VERSA) FROM THE PLANT (km)**						

Used Tyres	60	25	50	50	300	100	20
Industrial Slag	60	25			300	100	15
Glycerol	60	50	25	50	300	50	100
RDF	60		400		300	100	10
Sewage Sludge	60	25	20	20	300	100	20
Animal Meal	60	100	20	40	300	100	150
Used Oil (UO)	60	25	20	40	300	50	20
Biomass	60	100	50	50	300	100	150
Mineral Oil	60	50	25	50	300	100	20

Table 6: Distance (Both Ways) of sources of Wastes from the Plants (km)

2.1 Forecasts for the Use of AF in Greek Cement Industry (GGI)

GCI PRODUCTION	
	CAPACITY (MT)
CLINKER	13.1

2.1.1 Forecasts of thermal consumption in 2008 – 2012

	THERMAL ENERGY
TYPE OF FUEL	TJ
ALTERNATIVE FUELS (AF)	2999.4
CONVENTIONAL FUELS (CF)	43636.6

Table 7: Thermal consumption of GCI in 2008 – 2012

2.1.2 Forecasts of thermal consumption of using Alternative Fuels in 2008 – 2012

	CAPACITY	**CALORIFIC VALUE**	**THERMAL ENERGY**
TYPE OF FUEL	**TONS**	**MJ/KG**	**TJ**
Used Tyres (UT)	15000	31.4	471.0
Industrial Slag (ISL)	15000	15.5	232.5
Glycerol	11000	12.5	137.5
RDF	80000	14	1120.0
Sewage Sludge (SS)	25000	14.5	362.5
Animal Meal (AM)		19.1	
Used Oil (UO)	1500	35.2	52.8
Biomass		17.5	
Mineral Oil (MO)	15500	40.2	623.1

Table 8: Thermal consumption of using AF from GCI in 2008 – 2012

2.1.3 Forecasts of thermal consumption of using Alternative Fuels in 2012 – 2016

	THERMAL ENERGY
TYPE OF FUEL	TJ
ALTERNATIVE FUELS (AF)	9313.7
CONVENTIONAL FUELS (CF)	37322.3

Table 9: Thermal consumption of using AF from GCI in 2012 – 2016

2.1.4 Forecasts of thermal consumption of using Alternative Fuels in 2012 – 2016

	CAPACITY	**CALORIFIC VALUE**	**THERMAL ENERGY**
TYPE OF FUEL	**TONS**	**MJ/KG**	**TJ**
Used Tyres (UT)	30000	31.4	942.0
Industrial Slag (ISL)	22000	15.5	341.0
Glycerol	28000	12.5	350.0
RDF	280000	14	3920.0
Sewage Sludge (SS)	152000	14.5	2204.0
Animal Meal (AM)	4300	19.1	82.1
Used Oil (UO)	2000	35.2	70.4
Biomass	32000	17.5	560.0
Mineral Oil (MO)	21000	40.2	844.2

Table 10: Thermal consumption of GCI in 2012 – 2016

3. Pre-feasibility studies on the use of waste in the Greek cement industry

Until now we have seen that the amount of the used wastes as AF in Greece and especially in Cement Industry is very low (<1%). Although the available sources of wastes that exist in Greece are in very attractive quantities, their main disposal "way" is the landfilling. One of the most promising ways of their disposal y could be their use as AF in Cement Industry.

The waste disposal in national level varies from region to region. That means there are areas with well organized system of collection disposal and furthermore utilization of their wastes (Attica, Hania etc.) and there are areas that their disposal of wastes is concentrated to the landfiling of them. Consequently and as the European Community commits from every country to proceed in the recycling of their wastes setting relevant chronic limits, appropriate investments or improvements must be done in national level for the disposal of waste.

The wastes used as alternative fuels in cement kilns could alternatively either have been landfilled or destroyed in dedicated incinerators with additional emissions as a consequence. Their use in cement kilns replaces fossil fuels and maximises the recovery of energy. Employing alternative fuels in cement plants is an important element of a sound waste management policy. This practice promotes a vigorous and thriving materials recovery and recycling industry, in line with the essential principles of the EU's waste management hierarchy.

Having say all the above and because the cement manufacturing is a "high volume process" and correspondingly requires adequate quantities of resources, i.e. raw materials, thermal fuels and electrical power, it is obvious that the logistics of waste could effectively contribute to substitute bigger quantities of fuels and raw materials. Before starting to generate this assumption it is of potential importance to see the barriers and frameworks that didn't allow the wastes to be used as AF until now.

The energy policy in Greece is drilled by the Minister of Development in conjunction with the Regulatory Authority for Energy (RAE). Until recently, the Greek legislation for the use of wastes as AF could be characterized of recession, infectivity and complexity, having as a result the development delay for the use of wastes as AF.

Quite recently, the Minister of Development created a new law 3468/2006 which helps the adoption of waste or other renewable sources to substitute conventional sources of energy.

Also one of the most important targets that the national Strategic Energy Technology Plan, the Environmental Technology Action Plan, relevant European directives and national legislation lays is the use of increased quantities of Alternative Sources of Energy.

The European Commission, the Parliament and the Council have recently published their reviews of the Community Strategy for Waste Management originally established in 1989. All three documents have a certain flexibility regarding the application of the waste management hierarchy. The utilisation of alternative fuels in the cement industry is supported by the general principles of waste management at both European Union and national levels.

The rules for national regulation of cement plants are laid down at European level in the European Community Directive on the combating of air pollution from industrial plants (84/360/EEC). These rules are being replaced by those in the new Directive on Integrated Pollution Prevention and Control (96/61/EC) – the "IPPC" Directive. This new important environmental legislation aims at achieving a high level of protection for the environment as a whole by means of measures "designed to prevent or, where that is not practicable, to reduce emissions" to air, water and land.

The quality and specification of each waste that is intended to be used as alternative fuel to substitute the conventional fuels varies in a large range. That means that each company must know exactly about the process that must follow the trials and technical installations that must be done before the adoption of any kind of waste. The appropriate investments must not only include the way of the "burning" process of the waste but they must also take into consideration the storage of the waste before the "burning" process, the transportation of the waste to the interest plant, the passing way of these transportation through the local communities and the acceptance of them, etc.

The necessary condition to achieve all the above is the existence of a well organised web for the collection and disposal of wastes. Until recently the absence of such web was making the use of various types of wastes in cement industry to be prohibited. As the demand of using the wastes as AF than to dispose to the landfills becomes necessity, it is matter of time the development of such webs in all over Greece.

The actuation and harmonization of the GCI with the boundaries that European and national legislation set was quite late, compared with the European Cement Industry. That means that the adoption and use of such waste in their burning process is still under investigation and trials when in some European countries the correspondence industry has reached the amount of 25% (in energy consumption) of their CF by the use of waste.

Additionally the lack of a well organized "waste" web and the absence of appropriate technological substructures by the cement industry, leads to the export of some quantities of wastes that could preferably be used as AF by the Greek cement Industry.

The introduction of changes to long-established operations such as cement works can cause interest, or sometimes concern, amongst communities and other stakeholders. The cement industry engages with all interested stakeholders through regular, open communications about any aspect of its operations. The cement industry's key stakeholders include the neighbours/local communities, employees, customers, shareholders, regulators, 'green' issue interests and those who depend on the industry for their livelihood. However, experience has shown that the stakeholders who become most involved are the local communities and the regulatory bodies.

When any proposal is made to use an alternative fuel the cement manufacturer will include it in its open dialogue with stakeholders. This is done at the earliest possible opportunity through established 'open door' policies, formal open days, liaison committees and newsletters. During trials, reports on progress may be published weekly, supported by Forecasts for interested groups to see the fuel being used at first hand.

The elements that make up the regular dialogue develop with the communities' involvement, which brings advantages to both parties. Manufacturers are better able to incorporate feedback into their plans and the transparency of the process means that the community is involved, consulted and reassured.

Additionally the offer of some advantages in local communities would contribute positively in the acceptance of using such waste in the cement process production.

Also it is major obligation of the Greek government to inform and aim the local communities to understand that the use of such wastes under some specific conditions is better than to landfill them or dispose in other ways.

3.1 TECHNICAL-ECONOMIC STUDY

The study is divided into two periods and corresponds to the total sum of plants each Group owns. The first period (**PHASE I – 2008-2028**, the related investments shall be implemented in 2008 and will operate by September 2008), was based and chosen taking into account the following parameters:

- The current situation relatively with the potential existence of mature and reliable sources of AF as well as the trends which are emerging on the particular field of research.
- The need to use AF by the energy-intensive cement industry which developed strategies to reduce CO2 emissions, given the fact that the distribution of emission allowances among plants is rather fixed1.

[1] Greece signed the Kyoto protocol in April 1998 as other EU member states. All EU member states ratified the protocol in May 2002. Greece harmonised it into national legislation with the Law 3017/2002

- The need to comply to the national and EU legislation and the commitments that arise from the participation in international treaties, strongly related to the context of environmental protection and conservation.
- The high ability (technical, economic, managerial, etc.) of the concedely developed Greek cement industry to respond and adapt to its international and domestic commitments and challenges and to operate adequately in the strongly competitive – globalised environment of the specific sector.
- The stable and developed (economic, political, legislative, infrastructures, etc.) environment of the country and the highly skilled/trained available human resources.
- The very significant changes that occurred and will be occurring into the world caused by climate change and the urgent need for the developed countries to address the issue.

The second period (**PHASE II – 2012-2033**, the related investments shall be implemented in 2012 and will operate by September 2012), was based (apart from the aforementioned parameters) and on the topology of the sources of AF during that time, as it results (rather reliably since it is based on a set of plans and policies) from the developing progress of the sectors that produce AF and that will be able to produce AF's in terms of quantity as well as quality and in the context of dependability.

In order to use AF, Greek cement industry must make necessary investments and TITAN Group has already implemented relevant investments and turns into advantage even though in a low rate, AF in the facility that is situated at Kamari in Attiki, while as it is already presented all the Groups have designed appropriate plans for all of their plants.

A cost/benefit analysis for each one of the plants that operates in Greece is presented below, excluded the plant of TITAN's Group in Eleusina (because of the aforementioned reasons). For each of these plants two separate and independent cost/benefit analyses and one total are applied:

- One under the premise that the first set of related investments shall be implemented in 2008 and will operate by September 2008.
- And one under the premise that the second set of investments shall be implemented in 2008 but they will be operational by September 2012.

The objective of each analysis is on one hand to specify the revenues and costs and on the other hand to estimate the present value of the financial flows during that period (as well as the internal return ratio), which are indicative of the sustainability of these investments from a financial point of view exclusively. It is stressed once again that separate and independent cost/benefit analysis for each facility is presented below.

3.1.1 Assumptions

All the analyses are made under the following assumptions:

- The costs are calculated from September 2007 to 31/12/2028 for the first type of analysis, while for the second one they start from September 2012 to 31/12/2033 and refer to:
- The operational and maintenance costs, etc. (as discussed in each case)
- The reimbursement of the loan debt and the related interest of the investment costs (it is assumed that the total investment will be made with loan which will have a fixed rate of interest of 5%). The first reimbursement of the loan debt and the related interest of the investment costs starts in September 2008 and includes the trimester of 2007 for the first type of analysis, while, likewise, for the second group of analysis it begins in September 2012 and continues steadily till the end for both groups of analysis of each facility.
- The payment of tax on earnings 25%.
- Costs include VAT
- Revenues begin on September 2007 to 31/12/2028 for the first of analysis, while for the second one they start from September of 2012 to 31/12/2033 and refer to:
    - Revenues that flow from the anagoge of thermal energy which is produced from the combustion of AF to the thermal energy that is required for Coke and Pet Coke combustion (40/60 weight ratio) and then the cost that refers to the respective Coal quantities and Pet Coke plus the revenues from the inflow of AF's to the plant for their thermal destruction. In the chapter 7 depicts the aforementioned premises (based on Greek market's present time data – 2007 – and referring to prices of delivery to the plant). These prices are regarded fixed during all the years of analysis and on the cases of investment on 2008 and on 2012 respectively.
    - Revenues from sales, for 5€/tn CO_2 (this price reflects the net revenues after the subtraction of all types of costs related to this fund). Quantities of these CO_2 tns derive from the following subtraction; CO_2 quantity that would be emitted if, as above, Coal and Pet Coke was used minus the CO_2 quantity that will be emitted from AF plus CO_2 quantity plus CO_2 quantity that will be emitted from AF

- Baseline year for both types of analysis of each facility is 2007, present value prices
- Operating periods 2008-2028 (PHASE I) for one group of analysis and 2012-2033 (PHASE II) for the other. The case PHASE TOTAL is from 2008 until 2033.
- Rate of interest 5%
- Remaining value as rate of the initial investment (10% of the initial value of the Electro/mechanical (E/M) works, 50% of the initial value of the Civil engineer works C/E)
- Initial assessment's cost, 3% of the of initial investment cost
- Maintenance cost of C/E works, 2.5% of the initial value of C/E works
- Maintenance cost of civil engineer works projects, 1.5% of the initial value of civil engineer works projects
- It is assumed that during the first year of operation the facility will operate at 25% of its potential efficiency, from September 2008 and from September 2012 respectively.

3.2 Cost BenefiT and Sensitivity Analysis

A cost/benefit analysis for each one of the plants that operates in Greece is presented below, excluded the plant of TITAN's Group in Eleusina (because of the aforementioned reasons).

The following tables present the premises on the AF which will be used in each plant and in the cases of independent investments in 2008 and in 2012 respectively.

	Average calorific value	**Cost[2] of waste per ton delivered to the plant**		**Cost of CO_2 emisions[3]**			**Parity**
TYPE OF FUEL	GJ/TON	$/TON	€/TON	Kg CO_2/GJ		€/TON CO_2	€/$
COAL	27.2	150		92.8	(CSI default)	5.0	1.44
PET-COKE	31.4	135		96.0	(IPCC default)		
FUEL[4]	39		600		(IPCC default)		
Used Tyres (UT)	31.4		20	85.0	(IPCC default)		
Industrial Slag (ISL)	15.5		0	83.0	(CSI default)		
Glycerol	12.5		20	132.4[5]			
RDF	14		35[6]	75.0	(IPCC default)		
Sewage Sludge (SS)	14.5[7]		25	110.0	(IPCC default)		
Animal Meal (AM)	19.1		20	89.0	(IPCC default)		
Used Oil (UO)	35.2		30	74.0	(IPCC default)		
Biomass	17.5		-10	110.0	(IPCC default)		
Mineral Oil (MO)	40.2		-30	79.0	(IPCC default)		

[2] The (+) or (-) symbols that the plant is paid or have to pay to accept these type of waste. Value after interest and taxes.

[3] Value after interest and taxes.
[4] Heavy Fuel Oil
[5] Glycerol (which contains 20% water): 1.655/ X GJ/tn = ψ (Th. Bakalis)

[6] This price corresponds per ton of waste in the recycling factory. The price that this type of waste is delivered on the cement plant varies from the distance between the recycling factory and each cement plant.

[7] This value corresponds for "dry" SS with 7% humidity.

3.3 Results from All Cement Plants

PLANT 1	CASES		
	PHASE I	PHASE II	TOTAL
Variable costs	417 340 €	569 300 €	842.640 €
Fixed Costs	1 589 000 €	1 991 000 €	2.540.000 €
BEP	**41,44%**	**23.00%**	**31,30%**

PLANT 2	CASES		
	PHASE I	PHASE II	TOTAL
Variable costs	107 215 €	386 545 €	475.010 €
Fixed Costs	465 000 €	1 625 000 €	1.584.000 €
BEP	**73%**	**39%**	**48%**

PLANT 3	CASES		
	PHASE I	PHASE II	TOTAL
Variable costs	113 010 €	336 800 €	429.310 €
Fixed Costs	535 000 €	1 645 000 €	1.516.000 €
BEP	**79%**	**46%**	**53%**

PLANT 4	CASES		
	PHASE I	PHASE II	TOTAL
Variable costs	186 610 €	308 100 €	430.210 €
Fixed Costs	813 000 €	1 545 000 €	1.502.000 €
BEP	**78%**	**56%**	**63%**

PLANT 5	CASES		
	PHASE I	PHASE II	TOTAL
Variable costs	202 170 €	347 280 €	483.450 €
Fixed Costs	1 121 000 €	1 625 000 €	1.750.000 €
BEP	**59%**	**31%**	**40%**

PLANT 6	CASES		
	PHASE I	PHASE II	TOTAL
Variable costs	113 010 €	377 400 €	463.910 €
Fixed Costs	586 000 €	1 715 000 €	1.653.000 €
BEP	**78%**	**36%**	**46%**

PLANT 7	CASES		
	PHASE I	PHASE II	TOTAL
Variable costs	106 450 €	188 550 €	274.500 €

Constant Costs	510 000 €	1 227 000 €	1.191.000 €
BEP	**80%**	**53%**	**61%**

4. CONCLUSIONS

Although there are the suitable circumstances and sources for the renewable energy of wastes as the current main way of their management is to disposal on the landfills than to use them as thermal source of energy. Consequently the current use of AF, concentrated to the use of used tyres, sludge from refineries mixed with sawdust and glycerol, in the GCI is very low (<1%) compared, on thermal basis, with the average value in European Community. The stricter European and Greek legislation for the emissions and the use of AF in the cement industries and the uncontrollable rise of the price of the conventional fuels makes the use of AF more than a necessity.

The most promising waste streams that this report shown, concentrated to the burning of sewage sludge, RDF, glycerol and sludge from refineries. Some other waste streams although they are of high calorific value (used tyres, waste oils) and easy to dispose, the regularly framework and mainly the local community reactions do not allow their adoption as AF for the future. However, there are quantities of waste that are promoting renewable energy sources (non hazardous municipal solid wastes, agriculture and organic waste, animal meal, bone meal and animal fat etc.) and their landfilling disposal is a major environmental problem. Consequently this amount of waste (which must satisfy user standards) is a promising source for furthermore thermal utilization in the cement industry.

The most important piece of EC legislation with regard to waste alternative fuels utilisation in industrial processes is the Waste Incineration Directive (2000/76/EC) which aims to bring closer the requirements for incineration and co-incineration. This is going in the right direction to address the concern of environmentalists that industrial plants co-incinerating waste derived fuels are not as strictly controlled as waste incinerators. The implementation of the EC Landfill Directive (1999/31/EC) has an indirect impact on AF (RDF, used tyres, sewage sludge) production in Greece.

The legislative changes in the Incineration Directive appear to move matters in the right direction in seeking to harmonise standards as far as possible across co-incineration facilities and incinerators. But they do not go far enough. Greece is implementing policies in respect of climate change and control of greenhouse gas emissions which will also have an impact upon the use of AF in co-incineration facilities.

Use of RDF in industrial processes offers more flexibility than incineration. It leaves more opportunity for future recycling programmes, it does not need to be fed with a constant amount of waste and it does not require investment in capital intensive dedicated incineration facilities.

Use of RDF in coal power plants and cement works, due to the effective substitution of primary fossil fuels, shows a large number of ecological advantages when they are compared with the alternative combustion in a municipal solid waste incinerator as long as the plants comply with the Waste Incineration Directive (2000/76/EC). However, dioxins/furans and mercury emissions might be problematic when RDF is co-incinerated in industrial processes and special measures should be developed (permits, amending 2000/76, and/or minimum quality standards for RDF).

There is a need to study the increase of heavy metals in cement and other by-products from co-incineration facilities to investigate possible environmental consequences this may cause.

Market mechanisms may favour inclusion in RDF of fractions that could be recycled in favourable environmental and economic conditions. This phenomenon could increase for some types of RDF (i.e. biomass waste) as a consequence of Directive 2001/77/EC on renewable sources of energy.

The benefit of using RDF as fossil fuel substitute at industrial plants must be secured by adequate controls on emissions and the quality of input materials. The simplified environmental assessment on possible negative impacts of the surroundings of a plant burning RDF leads to similar conclusions: With the given assumptions of average to advanced technologies in the EU for power generation, cement works and MSW incinerators, and typical conditions regarding chimney stack controls and climate, no severe environmental impacts will be observed on a local level. Nevertheless dioxins/furans and mercury at the cement works are the weak points for the use of RDF even if they are still below the 2% threshold of air quality guidelines. Primary (regarding content of these heavy metals in RDF) and secondary (cleaning systems at the plants) measures are needed to control these potential weak points.

Waste derived fuel (from MSW production and from other sources) and its utilisation is viewed in some countries as a strategic component of an integrated waste management policy, as the landfill outlet for MSW is increasingly restricted by EC and Member State legislation.

In Greece (and in other countries as for example Spain, Ireland, Italy, Portugal, UK) where source separation is not so well-developed and where source separation with or without residual waste treatments might be sufficient to meet the Landfill Directive targets, flexibility in waste management options will be very important.

Technologies chosen for AF utilisation should be based on an average to advanced high standard (in respect to BAT).

Greece should decide (as already has made Italy) that electricity from fuels derived from MSW constitutes 'renewable electricity' production even though this is not covered by the Renewable Energy Directive 2001/77/EC. Italy argued that co-incinerating RDF in dedicated or industrial processes to generate energy can help to reduce greenhouse gas emissions and so help to achieve their commitments to the Kyoto protocol. This appears true if, and only if, the material being combusted is genuinely a residual material (i.e. material which cannot be recycled).

From the results that were extracted by the above economical analysis, it can be concluded that:

The use of AF as substitution of CF is very attractive giving quite big values of IRR, B/C even in the worst considered case, while the BEP decreases in all considered cases after the first years of operation. All the investment and operational costs are covered in a quite early time from the considered operation beginning point of the project.

As the management and logistics of various types of wastes becomes better, the benefits that the plants are earned are quite positive. These benefits are not only concentrated on economical interest but also show social and environmental benefits.

The most promising wastes are those of sewage sludge, RDF and solid wastes but under special condition.

The wastes used as alternative fuels in cement kilns would alternatively either have been landfilled or destroyed in dedicated incinerators with additional emissions as a consequence. Their use in cement kilns replaces fossil fuels and maximises the recovery of energy. Employing alternative fuels in cement plants is an important element of a sound waste management policy. This practice promotes a vigorous and thriving materials recovery and recycling industry, in line with the essential principles of the EU's waste management hierarchy.

The rules for national regulation of cement plants are laid down at European level in the European Community Directive on the combating of air pollution from industrial plants. The stricter European and Greek legislation for the emissions and the use of AF in the cement industries leads the GCI to start using the AF as a substitution of conventional fuels in greater rate from the quantities that where used until nowadays. The investment and the results that this analysis showed are quite attractive for all investigated plants of the Greek Cement Industry. It is a matter of the Cement Industry to adopt or not this kind of solution.

In order to achieve all these aims is of essential importance for the cement industry the sincere, developed corporation and good relationship of open doors with the local communities.

D15: Pre-feasibility study report / Bulgaria

SEC carried out an Assessment and Analysis of Alternative Fuels and Raw Materials in Bulgarian Cement Industry.

The introduction of new technologies for use of alternative fuels and raw materials is:

- a matter of legislation;
- a matter of know-how and investment possibilities for introduction of new technologies and
- a matter of supply of necessary alternative fuels quantities.

As the Bulgarian cement industry is owned by the leading European companies, which have the necessary technologies and investment possibilities, our analysis focused on studying the existing legislation base and the situation and conditions of supply of the waste as alternative fuels and raw materials.

The method, which applied includes studying of:

- The international experience of alternative fuels and raw materials utilization in the cement industry in order to make a comparison to the situation in Bulgaria;
- Mapping of the existing Bulgarian cement industry with emphasis on the status of cement plants and utilization of wastes as alternative fuels and raw materials;
- Waste management in Bulgaria and potential for exploitation by the cement industry. The main aims of this analysis are:
    - Waste streams;
    - Waste collection, transportation and treatment;
    - Waste management legislation and policy;
    - Waste management actors.

- Feasibility of waste exploitation in the Bulgarian cement industry.

On the basis of the results of the study the following barriers and main conclusions were developed:

- No incentives for collection and sorting of waste.
- The logistics of wastes needs significant improvement in order for the cement plants to be supplied with the necessary waste streams regularly and from regional sources in order to be economically viable.
- Unreliable and in most cases missing data on waste sources and treatment facilities.
- No implementation of Waste Action Plan.
- As waste incineration for energy recovery is relatively further on the waste hierarchy, some of the waste streams (such as car tyres) are reused or recycled and do not end up in the cement plants.
- The waste management and climate change legislation in Bulgaria both favor the introduction of alternative fuels from waste in the cement plants. Different measures are envisaged for organizing the waste management in a way to encourage such utilization. However for the time being additional efforts are needed to enforce the legislation.
- The state and municipalities do not play the necessary role in improving the organization of waste management.

Main conclusions:

- Technologies for utilization of wastes as alternative fuels and raw materials already exist in Bulgarian cement industry.
- The potential of substitution of conventional fuels is assessed at about 40%, having in mind the use of new technologies and the fact that in Bulgaria currently almost no waste is used in the cement plants.
- All stakeholders show interest and invest in co-processing of waste in cement plants.
- Most of the cement plants have made the necessary investments for introduction of technologies for use of alternative fuels and have been issued complex permits by the Ministry of Environment and Water for use of such fuels. There are successful practices of using car tyres, animal meal, and industrial waste as alternative fuels in some of the plants. In the case of animal meal and car tyres the state is envisaged to pay for their incineration.
- The incentives for utilization of wastes as alternative fuels and raw materials are:
  - Economic: the high energy intensity of the industry and the rising energy prices make it more and more economic to use alternative fuels;
  - Apart from the economic benefits for the Bulgarian cement industry, utilization of wastes can reduce the environmental problems due to landfilling and help in meeting the international environmental commitments.
- The State adopted policies for encouragement and support the use of alternative fuels and raw materials in the cement industry. The Bulgarian legislation is also in complete harmonization with the EU requirements. However, there is still ineffective enforcement and much more should be done for its practical implementation.
- The State and the municipalities have to play a significant role in improving the organization of waste management, development of infrastructures and mechanisms for waste logistics.

D16: Pre-feasibility study report / Romania

TRAPEC carried out a **market survey** regarding the sawdust potential in the region of Câmpulung (50 km around the cement plant) which took place during the month of November 2007. A specific questionnaire has been prepared and sent to 27 wood processing companies. These companies had been found through the internet and by contacting the local Environmental Agencies which had a database regarding wood processing companies. In the same way, 14 town councils had been contacted. Unfortunately, very few of the wood processing companies answered to the questionnaire and most of them preferred to respond by phone, arguing they didn’t have time. It has also to be highlighted that a number of wood processing companies are mobile, i.e. that they are present in the region for a limited period of time. For this reason, they were not taking into account in this survey. Nevertheless, the obtained results of the survey show that an important amount of sawdust is available in the Câmpulung region. The information collected shows that more than 700 tons of sawdust are weekly produced, most of it being available to be recovered as fuel. The sawdust is 50% moisture content.

Starting from this conclusion, a prefeasibility study has been performed at the Câmpulung cement plant in order to see the possibility to use the available sawdust as alternative fuel. First, information regarding the Câmpulung cement plant has been collected in order to see what kind of technology and fuel are in use, and how the use of sawdust as alternative fuel can influence the cement production process. The cement plant from Câmpulung was founded in 1971 and has been acquired by Holcim in October 1999. Câmpulung cement plant is a dry process, 4 stage preheaters cement producing plant and has an operating clinker capacity of 3 kilns x 850 t clinker/day. All its kilns are multi-fuels burners. The plant produces more than 1million tons of different types of cement each year (production showing an accelerated increase in the last years, according to the market demand) and consumes about 2.8 million GJ for producing the necessary clinker. This heat is assured by burning of traditional fuels, but also of the alternative fuels (waste as such or pre-processed). The multi-fuels kiln burners allow a sawdust substitution rate up to only10%. In present, alternative fuels in the cement production process represent about 2,5% of the total fuel.

In order to develop the technical analysis, contact had been taken with the company KHD Humboldt Wedag GmbH. Information provided by this company, together within formation provided by Holcim (Romania), SA itself allowed setting up 3 different scenarios, using sawdust as alternative fuel, as described below:

Solution 0 – 10%: use of the actual kilns with a substitution rate of 10%No changes are done to the kilns burner. The only changes into the cement plant concern the equipments to handle and transport the sawdust inside the plant;

Solution 1 – 30%: use of the actual kilns with a total substitution rate of 30%Impregnated sawdust will be considered. The sawdust substitution rate is therefore up to 15% of the total amount of used fuel;

Solution 2 – 45%: use of the actual kilns together with calciners, with a total substitution rate of 45%Impregnated sawdust will be considered. In this case the sawdust substitution rate is up to 21% of the total amount of used fuel.

Once the scenarios set up, an **economical analysis** has been done. For this, several parameters had been taking into account. Between others, it can mention:

- Transport's cost which depends of the covered distance between the "sawdust production" locations to the Câmpulung cement plant.
- The storage area has been calculated taking a monthly use basis. It has been considered a covered stock area for the total amount of sawdust collected during one month, for each solution.
- Sawdust drying machine had been considered, allowing to obtained sawdust with 50% moisture content to sawdust with 20% moisture content.

The investment for equipment which has been taking into account in the pre-feasibility study, for each solution, is presented in the table below:

	Description of the equipment	**Investment (euro)**
Solution 0 – 10%	Sawdust dryer (x3); Storage building; Handling and transport	1 452 250
Solution 1 – 30%	Sawdust dryer (x4); Storage building; Handling and transport	2 105 300
Solution 2 – 45%	Sawdust dryer (x6); Calciner (x3); Calciner's building (x3); Storage building; Handling and transport	20 526 400

For the economical analysis, it has been considered 3 different situations as described below:

i) the Câmpulung cement plant has to pay the wood processing companies to acquire sawdust;

ii) the sawdust is acquired by the Câmpulung cement plant for free;

iii) the wood processing company has to pay the cement producer in order to get rid off its sawdust: concept of "polluter-payer".

Finally, an **environmental analysis** has been developed in order to see the benefits bringing by the use of sawdust as alternative fuel in the cement industry. Taking into account that the Câmpulung cement plant is mainly using coal and petcoke, per annum, the use of sawdust in the Câmpulung cement plant allows saving from more than 20 000 tons of CO_2 for Solution 0 – 10%, up to almost 44 000 tons of CO_2 emissions, corresponding to Solution 2 – 45%. For these calculations, it has been considered that impregnated sawdust is formed by 50% of sawdust and 50% of petroleum waste. Moreover, an average value of 93 kg CO_2/GJ has been considered as emission factor for traditional fuels.

The **main conclusions** of the prefeasibility study developed in the Câmpulung cement plant are the following:

-Sawdust helps to reduce indirect pollution avoiding the land filling of this sawdust and its consequences as well as it allows saving of CO2 emissions at country level. For a substitution rate of 45% of conventional fuel, up to 44 000 tons of CO2 emissions can be saved.

- In an economical point of view, the use of sawdust is really efficient only if the concept of “polluter – payer” is applied. Moreover, appropriate investments had to be made in order to improve the kilns of the Câmpulung cement plant, allowing a higher substitution rate of conventional fuels.
- Solution with calciner is more flexible in term of alternative fuels. In fact, this solution allows processing a higher number of alternative fuels, namely alternative fuels with “low quality” properties. This point can be a great advantage if the Câmpulung cement plant plans/has the opportunity to process more type of alternative fuels. For this reason, a deeper study has to be done regarding the possibilities to use a larger range of alternative fuels, including sawdust.

D17: Pre-feasibility study report / Cyprus

The pre-feasibility study conducted by Vasilikos Cement industry. The study aims to evaluate the current situation of the cement industry and later on to the research of its future prospects aiming on strategic planning an action plan that will ensure the viability and quality of its provided services.

The Alternatives fuels that are nowadays used at the Vasilikos Cement are estimated to 6% of its total energy consumption. The Alternatives Raw Materials that are nowadays used at the Vasilikos Cement plant are: 80000 tns/yr of limestone and 80000 tns/yr granulated slag and all fired through 3rd generation burners.

The Cement Sector prospects are to utilize in the near future (2010) alternatives fuels that could replace 63000 tns of pet-coke (35% replacement). The amounts required will reach 20000-140000 tns of AFs annually. The cement sector will have the availability to start utilize RDF or mixture of RDF with stabilized organic matter (green coal).

Today in Cyprus the following quantities of AF are available:

- 5000-6000 tns of wasted tires.
- 25000 tns of sewage sludge from swage systems (equivalent to 8750 tns of dry sludge)
- 250-300 thousand tns of home waste from the cities (137500-165000 tns fuel)
- 3000-4000 tns olive seeds
- 500-1000 tns flammable solvents and other possible material.

From the above mentioned, Vasilikos Cement Industry came to the need for use of biomass and especially Green Coal. It’s a project for evolving the foundations for the technological and financial development of the Cement Industries.

Pre- feasibility Study

a. *Cost of the Project*

For the creation of the Green Coal Utilization Unit it was required to refurbish the current oven, which was out of order for years in the facilities of Vasilikos Cement Industry. Some special modifications were applied to the oven in order to produce odourless solid fuel out of garbage which otherwise would need to be dumped. The MSW is processed in a rotating drum.

By modifying an old kiln which was idle for years it is managed to save on the investment cost of € 3440000 by spending only 120000 US$ only.

b. *Production (per year)*

Organic waste: 75000

Green Coal production: 30000

Days: 300

c. *Transport Cost to VCW*

Tones per trip: 11

Cost per trip: 154.8 €

Transport cost per tone: € 14.07

Total transport cost: € 422183 /yr

Regarding the Gate Fee it is set to Zero.

Regarding the gate fee a re-evaluation of its cost is expected by the Government officials.

d. *Pet coke replacement (by 30000 tns green coal) – Attractive forecast*

Pet coke saving: 13072 tns/yr

Pet coke CV: 7600 kcal/kg

Pet-coke price: 63.6 €/tn

Green coal CV (at burner): 3500 kcal/kg

Pet coke replacement rate: 46.1%

Pet coke replacement saving: 27.7 €/tn green coal

Total Benefit: € 831711 per year

e. *Personnel*

For the operation of the new unit it is estimated that a total of seven people are to be employed which they will be split in two shifts of operation. The cost for employing those people will come to € 264880 per year with average cost per employ € 18920 per year.

f. *Electricity cost per year*

KWh/ton produced: 32

€/MWh: 103.2

Electricity cost: € 99072

g. *CO2 emissions reduction*

Tones CO_2 per tone of Green Coal: 1.43 per year

CO2 price: € 20.64 per ton

Saving per tone Green Coal: € 29.52 per year

Total Saving: € 885456 per year = (30000 x 29.52)

During the pre-feasibility study two cases were studied:

In the fist case the CO_2 emissions were taken into consideration where in the second case not.

Studding the values of NPV and IRR it seems that it was expected that the investment would be viable only in the case that the CO_2 emissions was taken under consideration.

The CO_2 emissions criteria are very important. They are already discussing in Cyprus the strict limits of CO_2 emissions in the industry, affecting the Cement industry in a great level. With the cost of CO_2 reaching 20€/t and having to pay in the future penalties for excess of CO_2 emissions, is means that the Cement industries will have to face great costs in case of high emissions. The effort of the Cement Industries for pet-coke replacement with green coal will financially help them making the investment more viable.

The investment is expected to be paid back within five years.

Studying the NPV = 5.453 and the IRR = 9,06% it was concluded that the investment is viable. The investment is expected to pay of within five years.

Analysis of project´s key factors:

- Economic and financial sustainability ⇨ Favourable
- Technical sustainability & product quality ⇨ No change of the product quality is observed by using AFs. The quality assurance dept. regulates the raw material composition once AFs are used, after observing the quality of the product clinker.
- Environmental/ecological sustainability ⇨ both external and environmental impact factors are in favour of firing AFs in the Cement kiln than utilizing or treating them otherwise (e.g incineration). Life cycle analysis is also in favour of cement plant firing.

D18: Pre-feasibility study report / Turkey

The focus of the national strategy has been shifted directly towards logistics and productivity rather than doing a pre-feasibility study beforehand. Paralelling this concept, a realistic objective set has been established focusing on the logistics of waste and the strategy of promoting the utilization of the alternative fuels, and the more productive consumption of raw materials in larger quantities throughout the sector in the future.

This objective spectrum has been translated into an umbrella of focused action plans, clearly defining the roles of the parties involved as well as determining the process metrics. These action plans have been constructed to render them cost -effective within the available current data context pertaining to the cement sector.

Sector analysis reports, scientific research findings, proceedings of the meetings targeted at the various aspects of the cement sector, Ninth Development Plan of Turkey were just some of the aspects of the data base on which the strategies were developed and refined.

In addition site visits were made to several cement plants and meetings were held with the cement managers and technicians where our approach was discussed in detail and our findings on the related plants were checked.

Data mining procedures were carefully followed to ensure both the prioritization of the present issues and the forecast modelling of the probable future. On the other hand, data mining related to policy and strategy allowed the sectoral picture to be depicted by all the stakeholders in detail.

A range of future scenarios are taken into account to establish the pillars of the strategy mapping of the future-oriented interrelated factors matrix. Contingency plans have been formulated to assure the risk management perspective of the picture as a whole.

D19: Analysis of the legal and policy framework / EU

An analysis of the legal & policy framework; policy recommendations for further exploitation of AF and AM in cement industry at EU level has been elaborated by Van Heekeren & Frima. The main findings are presented in the following.

One overall finding was at the end of the day, that technology was not really the most important issue or constraint in this domain. For one thing the ENCI cement kiln (Heidelberg Cement Group) was built in the sixties and is fuelled by more than 90% of alternative raw materials. More modern multi-stage kilns should be at least as capable of handling similar alternative fuel loads. Also in most investigated cases it is also not a lack of technical know how. Most of the cement plants are subsidiaries of larger multinational concerns and are quite capable of implementing the technology. But as discussed before: more is not necessarily always better. For each larger stream of alternative fuels a careful and objective Life Cycle Analysis of the total process compared to the available alternative options would be useful. As the objectivity of these studies is served by independent funding, it is recommended that funding is made available to perform these LCA studies and, more important, to have the results in the public domain.

An obvious recommendation is to encourage faster introduction of sound waste management policies. The knowledge generated in the studies above could contribute to the development of these policies. But the issues and concerns of the cement industry – though important – are not and should not be the driving force. The driving force should be internationally accepted sound waste management strategies - and the cement industry might well benefit from this.

A separate item is perhaps the use of alternative raw materials in casu blast furnace slag. This option has few negative side effects and is generally considered to be recommendable. The effects on CO_2 are substantial. One ton of BF slag avoids roughly one ton of CO_2. In The Netherlands approximately one mln tons of CO_2 emissions are avoided – at basically zero cost to society. The product, blast furnace cement, is for some applications even to be preferred to the conventional Portland cement types. The transition to BF cement is however a long and difficult educational process in this predominantly conservative market of the building industry. It is recommended that the EU Commission reviews the options to assist the cement industry to adopt a higher percentage of blast furnace cement. This could be in the form of (modest) financial support for information sessions, knowledge transfer and especially initiatives to bring the steel and cement industries together. The BF option requires new or at least unusual cooperation between two fairly unrelated branches of industry and may not necessarily come by itself. The level of support could be modest, basically some funding of personnel (accelerators).

When looking at the major historical energy policy steps of the last 30 to 40 years one can see the following sequence. We – the then 12 member EU – started with energy conservation (efficiency) as a response to the oil crisis in the 70ties and 80ties. Major targets were the industry and the build environment. Heat was addressed more than electricity (and rightly so: energy consumption in the form of heat is an very important of overall energy consumption). Also: this – Heat and/or Industry - was (and still is) an area of comparatively quick wins. Pay back periods are way lower than other energy options.

Focus shifted in later years first to greening of electricity production. And after that the following trend was the shift towards green(er) automotive fuels. Carbon dioxide replaced the original driver of ‘independency and security of supply’. Both ‘heat’ and ‘energy efficiency in industry’ suffered to some extent as policies (and funds) were increasingly targeted to those new domains. Nowadays we must face that these policies might be readjusted again. If the EU wants to reach the proposed Co_2 targets without (re)addressing Heat and/or Industry it is going to be very costly. Also the implicit disadvantages of green electricity (costs, storage, negative effects on grids) and green fuels (costs, competition for land, food, water, and last but not least the growing concerns for the true well to wheel CO_2 balance) are becoming more apparent every day.

Now the domains of heat (both industry and other users – e.g. the build environment) still offers an enormous potential for energy efficiency, renewables and CO_2 reductions. And often at less costs per avoided ton of CO_2 – compared to green electricity and green fuels. So one obvious general policy recommendation would be to shift Heat again upwards on the agenda of ETS, ETAP (Environmental Technology Action Plan) and the Strategic Energy Technology Plan. We simply can not afford to focus. To leave this vast and relatively inexpensive potential untapped is costly and ineffective. The recommendation is therefore to better (re)integrate Sustainable Heat in these programmes.

D20: Pre-feasibility study report / Poland

IPiEO studied the feasibility of an investment on the use of AF in Cement Mill Ożarów. One of the key objectives of the Cement Mill Ożarów is to intensify the use of alternative fuels reducing the consumption of conventional fuels. Fuel is fed into the kiln in two streams: into calciner and through the main kiln burner. The basic fuel for the kiln is hard coal, supplied as appropriately prepared coal dust. Besides coal dust there is a possibility to burn alternative fuels in the kiln. Currently at the Cement Mill Ożarów, also the alternative fuel, in form of shredded combustible waste, is fed into the calciner. The fuel is fed by a specially adapted installation. Incineration of substitute fuels allowed replacing ca. 14% of heat energy needed for clinker burning in 2006.

Similar results can additionally be achieved by feeding alternative fuels to the main burner. This requires execution of relevant investment projects. Thus the cement mill management made a decision to build a warehouse and a feeding installation for alternative fuels. The planned investment project will consist of:

- replacement of the Swirlax burner with the Duoflex multichannel burner;
- construction of a warehouse for alternative fuels of storage capacity of 350 Mg;
- construction of a node for feeding alternative fuels to the main burner of the kiln, of capacity up to 5 Mg/h. The feeding node will consists of the following devices:
    a) loading tank of capacity of 5 m^3, in the bottom of which a scraper feeder with remote control of rotation speed shall be installed;
    b) belt conveyer, 600 mm width;
    c) cell lock with a mixing chamber and cut-off valve;
    d) air blower.

The node shall be automated and remotely controlled from the central control room.

The planned investment shall be located on the grounds owned by the investor. The warehouse and installation for feeding alternative fuels are close to the main kiln burner to minimize the inter-process transport. The hazardous and other waste can be used as alternative fuel.

The investment by the Cement Mill Ożarów will contribute to increase in the use of waste as an alternative energy source, thus resulting in the following advantages:

- for the community (people): a far-reaching solution for disposal of many types of waste produced by the community and industry,
- for ecology (the planet): environmentally sustainable waste management and saving of natural resources,
- for the cement mill (profit): cost effective replacement of natural resources leading to improvement in the company's competitiveness.

Together it is an example of Sustainable Development, which guarantees satisfying of needs of current generation without limiting possibilities of satisfying the needs of future generations.

D23: Design and development of the project WEB and STS sites

The ALF-CEMIND web site (www.alf-cemind.com) was developed to be a means for communication, as well as a vehicle for the presentation of collected data, case studies, events and project results. In the screenshot below you can see the home page of the web site.

During the project period, the average monthly visits and hits of the ALF-CEMIND website were:

	Monthly data
Total hits	4650
Total visits	330
Hits per Day	155
Visits per Day	10

The project internet site was established within the first 2 months of the start of the project and was regularly updated. EXERGIA still to be responsible for the maintenance of the site until this activity will be undertaken by a national cement industry association.

Furthermore, Microsoft Sharepoint Team Services was implemented to assist in the project's partner's collaboration and communication needs. This system provides better discoverability of information, better communication and better team processes.

D24: Design and publication of an information brochure

The information brochure was a major publicity and information dissemination tool that received wide distribution across conferences and public meetings in order to reach the largest possible number of stakeholders and interested parties of the cement industry. Its content based on the publishable summary of WP4 and technology related information.

The brochure was published in 2000 copies. The copies of the brochures were distributed for dissemination around Europe to the Consortium members and CEMBUREAU.

D25: Final workshop

The final workshop was addressed to the full spectrum of stakeholders from all countries and focused on the alleviation of the barriers and the development of cooperation opportunities in polygeneration with the use of alternative fuels in the cement industry.

Main results-conclusions of the workshop are the following:

It is expected in the future significant substitution of conventional with AF in all cement plants. Driving forces are:

- The CO_2 mechanisms and relevant CO_2 market;
- The increasing prices of pet-coke;
- The existing potential of AF and gradual development of collection/ handling infrastructures;
- The available technologies and technological progress
- The current use of used tyres and the ambitious future aim of burning waste oils as substitute of CF, despite their "high" calorific value, must overcome the stricter European legislation for the emissions and the local communities' reactions. This may not allow their adoption as AF in the future
- There is a potential of waste that fall into category of renewable energy sources (non hazardous municipal solid wastes, agriculture and organic waste, animal meal, bone meal and animal fat, etc). Their landfilling disposal is a major environmental problem. These quantities of waste are a promising source for further thermal utilization in the cement industry.

The effect of the project in the relevant stakeholders of the participating countries has been significant, as was reflected in the participation of many high level government officials and business actors in the workshops that were organised within the framework of the project. Apart from verifying the status of cement industry in Europe, a key finding that has been of great interest to almost all participating countries has been the consideration that the Cement industry can potentially become competitive in the international market in a controlled and organised manner using waste derived alternative fuels and raw materials. The political context along with the appropriate incentives (from the environment point of view) given to cement industry investors will determine to a great extent the actual uptake of the alternative fuels and materials' market in the participating countries.

The results of the project had an impact much wider than that associated with the participating countries, as they have been disseminated Europe-wide in collaboration with the European Cement industry' association CEMBUREAU.

2. DISSEMINATION AND USE

An overview of the project's undertaken and planned activities is set out below in the following table.

Planned/ actual Dates	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved
April 2007	Workshop	Cement industry stakeholders	Bulgaria	~40	SEC
October 2007	Workshop	Cement industry stakeholders	Cyprus	~20	CIE

May 2007	Workshop	Cement industry stakeholders	Greece	~40	EXERGIA
November 2007	Workshop	Cement industry stakeholders	Poland	~100	IPiEO (EXERGIA's sub-contractor)
November 2006	Workshop	Cement industry stakeholders	Romania	~40	TRAPEC
May 2007	Workshop	Cement industry stakeholders	Turkey	~100	MERKAT
October 2007	Press article	Cement industry stakeholders	EU-27	~2000	VAN HEEKEREN & FRIMA
September 2007	Press article	Cement industry stakeholders	EU-27	~2000	MERKAT, EXERGIA
December 2007	Workshop	Cement industry stakeholders	EU-27	~50	EXERGIA
October 2006	Initial project brief	CEMBUREAU members	EU-27	~100	EXERGIA
September 2007	Initial project brief	EU AF and ARM equipment manufacturers	EU-27	~40	EXERGIA
September 2006	Project website	Cement industry stakeholders	EU-27	10 visitors/ day	EXERGIA
September 2006	Intranet site	ALF-CEMIND partners	EU-27	6	EXERGIA
August 2007	Production of an information brochure	Cement industry stakeholders	EU-27	2000	EXERGIA
September 2007	Production of a technology guide	Cement industry stakeholders	EU-27	500	EXERGIA
December 2007	Dissemination of brochure	ALF-CEMIND partners	EU-27	1700	EXERGIA
December 2007	Dissemination of technology guide in CDs	ALF-CEMIND partners	EU-27	450	EXERGIA
November 2006- November 2007	Four press releases	Cement industry stakeholders	Bulgaria, Cyprus, Greece, Romania	600	SEC, CIE, EXERGIA, TRAPEC
March 2008	Abstracts of the Greek pre-feasibility study	Greek cement industry managers	Greece	30	EXERGIA