THE SIXTH FRAMEWORK PROGRAMME
for Research, Technological

Development and Demonstration

# ALF-CEMIND Project:

## Supporting the use of alternative fuels in the cement industry

## Specific Support Action

**Contract No: TREN/05/FP6/EN/S07.54356/020118**

# ALTERNATIVE FUELS AND RAW MATERIALS SOURCES IN GREEK CEMENT INDUSTRY

# EXECUTIVE SUMMARY

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# EXECUTIVE SUMMARY

This report is the deliverable of EXERGIA's work in the Work Package 3 of the Alf-CEMIND Project "ALTERNATIVE FUELS AND RAW MATERIALS SOURCES IN CEMENT INDUSTRY".

The report consists of two main parts. The first is about the international experience in the exploitation of Alternative fuels (AF) and Alternative raw materials (ARM) 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.

The production process for cement is energy-intensive and requires a large amount of natural resources for fuel and raw materials. There are four cement manufacturing processes, dry, semi-dry, wet and semi-wet. The dry process, the most frequently used nowadays (about 90%), using preheaters and precalciners, is both economically and environmentally preferable to the wet process because the energy consumption - 200 J/kg - is approximately half that for the wet process. Nevertheless, the choice of manufacturing process is primarily motivated by the nature of the available raw materials.

Energy efficiency improvements have great potential to reduce costs, while dramatically reducing the majority of pollutants generated from fuel combustion. It is pointed out that energy makes up about 40% of the cost of cement production.

In this context, energy costs and environmental standards encouraged cement manufacturers world-wide to evaluate to what extent conventional fuels can be replaced by alternative fuels, i.e. processed waste materials. Clinker burning is well suited for various alternative fuels.

In brief, 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.

| 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 alternative raw materials are used in the cement production process.

ARM 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 ARM 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 with progressive development.

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 the amount of the used wastes as AF in Greece and especial 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.

From the environmental point of view, the choice of fuels can affect greenhouse gas emissions. The overall priority for cement makers is the safe manufacture of high quality cement. The GCI is committed to achieving this objective in a sustainable way: environmentally, socially and economically. To achieve greater sustainability, it is essential that all available resources are used efficiently and effectively. The cement industry considers wastes, with some exceptions, to be alternative resources awaiting an appropriate use and is actively pursuing beneficial use within its manufacturing process. The Greek Government has committed itself to the EU Landfill Directive and other international agreements that aim to reduce disposal of wastes to landfill and to recover energy and materials from used tyres, packaging wastes, solvents and many other waste streams. The GCI is therefore, playing a vital role in helping to achieve the Greek's environmental objectives by utilising appropriate wastes as alternative fuels in the manufacture of cement via industrial ecology.

The applied methodology in order to estimate the economic components of an investment for further exploitation of AF and ARM in the Greek cement industry includes the following steps:

1. Annual revenues estimation

2. Annual costs estimation (operational expenditures) by type and in total. The following types of costs are examined: wages, expendable and spare parts costs, etc.
3. Operational surplus estimation and the related cash flow per year
4. Net Present Value (NPV) estimation per year
5. Internal Rate of Return (IRR) estimation per year
6. Cost/benefit ratio estimation
7. Sensitivity analysis based on criteria of the size of revenues
8. Breaking Even Point estimation as defined by the ratio:

From the results that were extracted by the 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 better land-planning of TITAN plants give them a clear advance for the utilization of bigger quantities of wastes compared with the other cement Groups.

The magnitude of HALYPS plant gives the advantage to use smaller quantities to achieve its aims.

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.