WORKSHOP 13th December 2007, Athens
"Alternative Fuels and Alternative Raw Materials in the Cement Industry, Findings and Results"

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

SSA TREN/05/FP6/EN/S07.54356/020118

Workshop on Alternative Fuels and Alternative Raw Materials in Cement Industry, Findings and Results

Hotel Imperial, December 13, 2007

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ALF-CEMIND Project I

- **Title**: Supporting the use of alternative fuels in the cement industry
- **Acronym**: ALF-CEMIND
- **Duration**: 18 months
  - Contract was entered into force on May 15, 2006
  - Effective starting date July 05, 2006
  - Duration 18 months from the effective starting date
- **Aim**: to assist the take-off of use of alternative fuels in the cement industry leading to energy, environmental, social and economic benefits
- **Targeted countries**: Greece, Bulgaria, Romania, Cyprus, Turkey, Poland
- **Partners**: EXERGIA – Sofia Energy Centre – TRAPEC – Van Heekeren & Frima – Cyprus Institute of Energy – MERKAT – IPiEO

ALF-CEMIND Project II

- **WP 1** Project management and coordination
- **WP 2** Technology transfer

  Tasks: 6 national seminars on AF and ARM technologies

  1 study tour in two cement plants and one sewage sludge treatment plant in the Netherlands and Belgium
- **WP 3** Preparation of pre-feasibility studies

  Tasks: Pre-feasibility studies carried out in Greece, Romania, Cyprus and Poland

  Assessment and analysis of the solid waste utilized as AF and determination of the barriers in Greece, Bulgaria and Turkey
- **WP 4** Consolidation of results and dissemination

  Tasks: Development of the project website: http://www.alf-cemind.com

  Preparation of an information brochure

  Technology implementation guide

International cement groups

Alternative fuel substitution rates by the world's 5 largest cement producers

Cement producer	Thermal substitution with AF (%)
HeidelbergCement (Germany)	17
Holcim (Switzerland)	13.4 (not including India)
Italcementi (Italy)	4.4
Lafarge (France)	10.7
Cemex (Mexico)	7.36

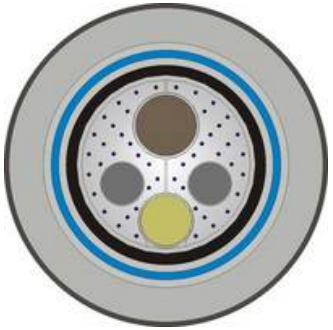
Substitution rates of waste fuels for cement production in various countries

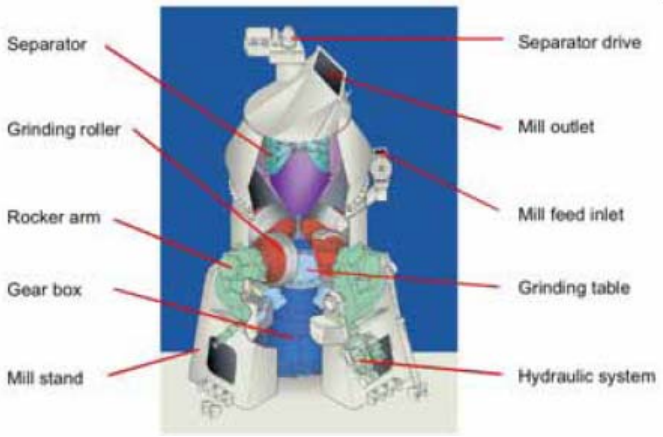
Country	Substitution rate (energy demand provided by waste) (%)
Belgium	>50 (55.6)
Czech Republic	45.3
Germany	42(3)
Estonia	37(5)
France	32(2)
Hungary	approx. 30(4)
Netherlands Austria	47-75
United Kingdom	up to 100
Norway	45
Switzerland	47(1)
US	25(2)
Romania	5.5
Denmark	4(6)
Finland	3(6)
Greece, Spain	~ 1(6)
Italy	2.1(6)
Luxemburg	25(6)
Poland	1(6)
Sweden	29(6)

(1) 2002, (2) 2003, (3) 2004, (4) 2006, (5) planned for 2009 (6) 2001

AF & ARM Technology Review I

- Co processing AF in cement kilns led to technological improvements and rearrangements for their handling, storing, conveying and injecting into the kiln
- A key equipment is the **multi-fuel burner** that enables burning of solid and liquid fuels simultaneously
- Grinding ARM is accomplished by means of traditional mills in various types. **Vertical mills** dominate the grinding process





AF & ARM Technology Review II

- **Handling** of AF is based on the rather conventional technologies used for various bulk materials
- **Transporting** complies with regulations for hazardous bulk materials
- **Storage methods** of AF and ARM within the yard of the cement plant depends on the type of material and associated danger. In most cases, special enclosed hangars or silos are used.
- Different types of **conveyors** are used to carry AF and ARM from the storage place to point of injection. Pneumatic conveyance is frequently employed
- **Injection** of AF into the kiln is achieved either via the multi-fuel burner or directly fed to the kiln (e.g. scrap whole tyres)

COMPOSITION OF AF & ARM

- Composition and characteristics of AF & ARM depend to a certain extend on the geographical region they are produced. RDF and Sewage Sludge are indicative examples
- Local habits and life styles do influence their composition, too
- Therefore each case should be addressed separately

History of AF & ARM penetration in cement production

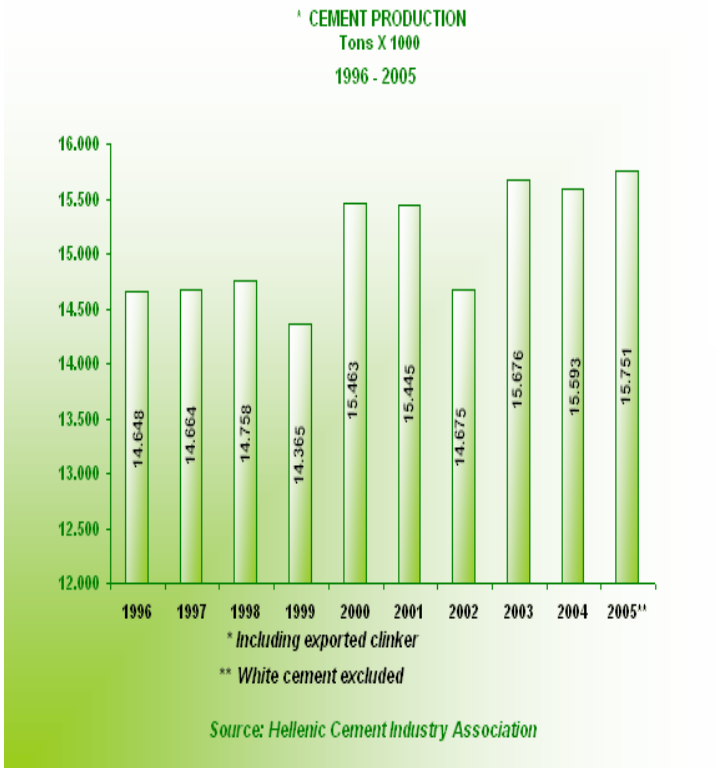
- Cement production is an energy intensive process being second to the steel and aluminium processing
- Increased energy prices of conventional fossil fuels (coal, oil, natural gas, etc.) and raw materials during the last years, attracted attention of cement plants for AF & ARM to enable them reducing the production cost
- AF & ARM contribute in saving fossil energy sources and materials
- AF & ARM reduce global CO_2 emissions by avoiding the combustion of conventional fuels

Success stories

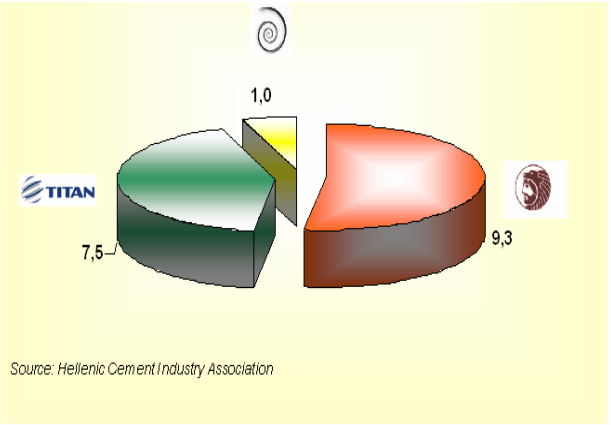
Plant in:

- Austria: Thermal substitution of >50% was achieved by injecting plastic chips of above 2.5 t/h
- Chile: Thermal substitution of >40% with up to 4 t/h sawdust and up to 2.5 t/h waste oil used
- USA – Atlanta: Replacement of 20% of traditional fuel used with scrap tyres (330,000 burned)
- India: 300,000 tons of fly ash and 800,000 tons of slag were used as ARM in 2002 saving 1,900,000 tons/y of limestone and decreasing CO_2 emissions by 800,000 tons/y
- Spain: Alternative fuel substitution of ~50%.
  AF used: solvents, waste oil, animal grease, animal meal, used tyres

The Greek Cement Industry I



- **HERACLES** General Cement Company
  - member of Lafarge Group
  - 3 cement plants in Greece
  - annual production capacity: ~ **9.3 million tons**
- **TITAN** Cement Company S.A.
  - Greek owned company
  - 4 cement plants in Greece
  - annual production capacity: ~ **7.5 million tons**
- **HALYPS** Building Materials S.A.
  - part of Italcementi Group
  - 1 cement plant in Greece
  - annual production capacity: ~ **1 million tons**



The Greek Cement Industry II

Summary of the thermal consumption in Greek Cement Industry in 2006

	THERMAL ENERGY	
TYPE OF FUEL	**TJ**	**%**
ALTERNATIVE FUELS (AF)	374.5	0.8
CONVENTIONAL FUELS (CF)	46261.5	99.2

The Greek Cement Industry III

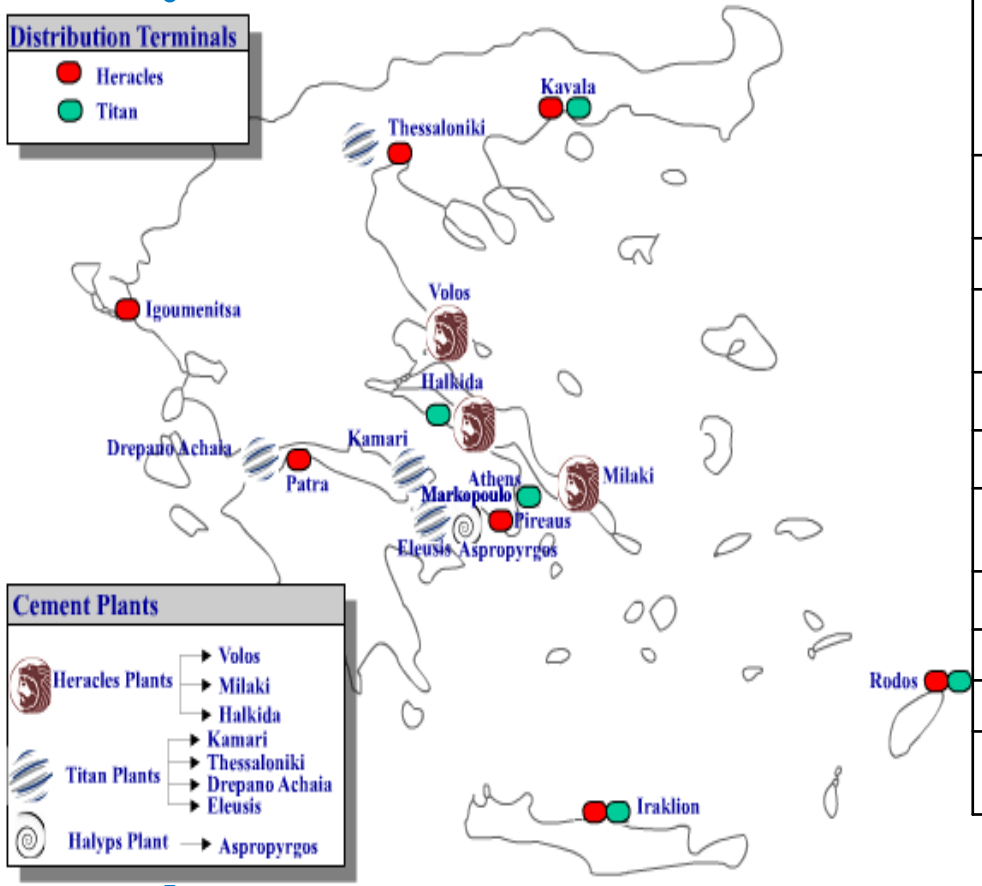
Thermal consumption and quantities of used Alternative Fuels in Greek Cement Industry in 2006

	CAPACITY	CALORIFIC VALUE	THERMAL ENERGY
TYPE OF FUEL	TONS	MJ/KG	TJ
USED TYRES	5000	31.4	157.000
INDUSTRIAL SLAG	10000	15.5	155.000
BIODIESEL (GLYCEROL)	5000	12.5	62.500
REFUSE DERIVED FUEL (RDF)		14	
SEWAGE SLUDGE		14.5	
ANIMAL MEAL, BONE MEAL (MBM)		19.1	
WASTE OILS		35.2	
BIOMASS		17.5	
USED MINERAL OILS		40.2	

Available Waste in Greece

AVAILABLE WASTES (TONS) THAT CAN BE USED AS AF AT THE PERIOD OF 2008-12					
TYPE OF FUEL	ATTIKI & ISLANDS	THES/NIKI	PATRA	VOLOS & LARISSA	TOTAL
USED TYRES	9000	3750		2250	15000
INDUSTRIAL SLAG	10000	5000			15000
GLYCEROL	3850	2750	4400		11000
REFUSED DERIVED FUEL (RDF)	80000				80000
SEWAGE SLUDGE	90000				90000
ANIMAL MEAL, BONE MEAL (MBM)					0
WASTE OILS		500		1000	1500
BIOMASS					0
USED MINERAL OILS	12350	4750		1900	19000
AVAILABLE WASTES (TONS) THAT CAN BE USED AS AF AT THE PERIOD OF 2012-16					
USED TYRES	9900	8100		12000	30000
INDUSTRIAL SLAG	15000	7000			22000
GLYCEROL	9240	7560		11200	28000
REFUSE DERIVED FUEL (RDF)	280000				280000
SEWAGE SLUDGE	90000	37000	12000	13000	152000
ANIMAL MEAL, BONE MEAL (MBM)	5250	4500		5250	15000
WASTE OILS	1400	600			2000
BIOMASS	4800	11200		16000	32000
USED MINERAL OILS	17080	8120		2800	28000

Distance (two-ways) of sources of waste from the plants (km)



CEMENT PLANTS	KAMARI	THESNIKI	PATRA	VOLOS	MYLAKI	HALKIS	ASPROPYRGOS
TYPE OF WASTE	DISTANCE (TWO-WAYS) 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
WASTE OILS	60	25	20	40	300	50	20
BIOMASS	60	100	50	50	300	100	150
USED MINERAL OILS	60	50	25	50	300	100	20

Distribution of waste

	DISTRIBUTION OF WASTES THAT CAN BE USED AS AF IN GREECE AT 2008 – 2012 (tons)							
	Used tyres	Industrial slag	Glycerol	RDF	Sewage sludge	Animal meal	Waste oils	Biom ass
TITAN								
KAMARI	5000	10000	1000	25000	25000		1000	
THESNIKI		5000	2600				500	
PATRA	4000		1000					
ELEUSIS								
AGET								
VOLOS	6000		4400					
MYLAKI				36000				
HALKIS			1000	10000				
HALYPS								
ASPROPYRGOS			1000	9000				
SUM TOTAL	**15000**	**15000**	**11000**	**80000**	**25000**		**1500**	

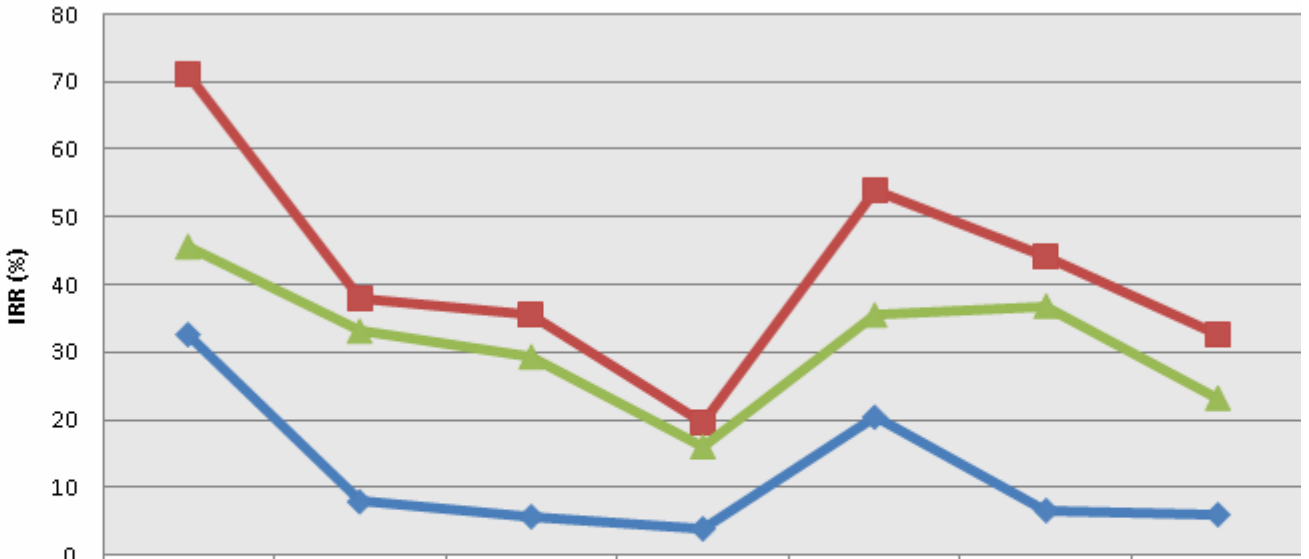
Opportunities of using AF at 2008-2012

	CAPACITY	CALORIFIC VALUE	THERMAL ENERGY
TYPE OF FUEL	**TONS**	**MJ/KG**	**TJ**
USED TYRES	15000	31.4	471.0
INDUSTRIAL SLAG	15000	15.5	232.5
GLYCEROL	11000	12.5	137.5
RDF	80000	14	1120.0
SEWAGE SLUDGE	25000	14.5	362.5
ANIMAL MEAL, BONE MEAL		19.1	
WASTE OILS	1500	35.2	52.8
BIOMASS		17.5	
USED MINERAL OILS	15500	40.2	623.1

Opportunities of using AF at 2012-2016

	CAPACITY	CALORIFIC VALUE	THERMAL ENERGY
TYPE OF FUEL	**TONS**	**MJ/KG**	**TJ**
USED TYRES	30000	31.4	942.0
INDUSTRIAL SLAG	22000	15.5	341.0
GLYCEROL	28000	12.5	350.0
RDF	280000	14	3920.0
SEWAGE SLUDGE	152000	14.5	2204.0
ANIMAL MEAL, BONE MEAL	4300	19.1	82.1
WASTE OILS	2000	35.2	70.4
BIOMASS	32000	17.5	560.0
USED MINERAL OILS	21000	40.2	844.2

Feasibility



	PLANT 1	PLANT 2	PLANT 3	PLANT 4	PLANT 5	PLANT 6	PLANT 7
IRR (Scenario 1) %	32.6	7.9	5.7	3.9	20.4	6.6	6
IRR (Scenario 2) %	71	38	35.7	19.7	54	44.1	32.6
IRR (Scenario Total) %	45.5	33	29.2	15.9	35.4	36.7	23.1

Forecasts

	2008-2012				2012-2016			
	AF (TJ)	CF (TJ)	% AF	% CF	AF (TJ)	CF (TJ)	% AF	% CF
PLANT 1	1152,6	7747,4	13,0%	87,0%	2498,6	6401,4	28,1%	71,9%
PLANT 2	248,2	5091,8	4,6%	95,4%	1333	4007,0	25,0%	75,0%
PLANT 3	258,7	4013,3	6,1%	93,9%	1085,7	3186,3	25,4%	74,6%
PLANT 4	404,2	12055,8	3,2%	96,8%	992,7	11467,4	8,0%	92,0%
PLANT 5	504	5192	8,8%	91,2%	1405	4291	24,7%	75,3%
PLANT 6	232,9	6887,1	3,3%	96,7%	1364,1	5755,9	19,2%	80,8%
PLANT 7	198,8	2115,2	8,6%	91,4%	634,7	1679,3	27,4%	72,6%
Total	**5800**	**84624**	**6,4%**	**93,6%**	**17992,9**	**72431,4**	**19,9%**	**80,1%**

Conclusions

Current situation in Greek Cement Industry:

- Alternative fuels were limited to the use of used tyres, slag from refineries mixed with sawdust and biodiesel (glycerol)
- Very small penetration rate (<1%), on thermal basis

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

Conclusions II

- According to the study, until the 2012 it is expected an increasing use of AF in the Greek Cement Industry
- The most promising waste streams in 2008-2012 concentrated to the burning of "dry" sewage sludge (Psitallia), RDF, glycerol, slag from refineries and used tyres
- 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 and Greek 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

Conclusions III

As a general conclusion:

- The development of use of AF/ARM in the Greek Cement Industry is currently very low but with significant potential for development
- Apart from the economic benefits for the Cement Industry, use of AF/ARM can relax environmental problems due to landfilling and help the country in meeting its international environmental commitments
- The State should adopt policies and encourage initiatives for:
  - Development of infrastructures and mechanisms for waste logistics, and
  - Encouragement and support AF/ARM investments in the Cement Industry
  - Promotion of the concept towards the local societies of AF/ARM as environmental friendly solutions
  - All these with respect to the EU and Greek environmental legislation and regulations

Waste streams used in the European cement industry

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