SELECTION AND USE OF ALTERNATIVE FUELS IN THE CEMENT MANUFACTURING PROCESS FOR GREECE, SWEDEN AND GERMANY

Critical Comparative Analysis of Using Waste ηn the Cement Industry Between Greece, Sweden and Germany

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ABSTRACT

As the cement production industry grows and adapts to new technologies and innovations, qualified methods of using alternative fuels will play an important role in ensuring the profitable operation of facilities well into the future. As the world looks to a carbon-neutral future, the energy transition is supported by the dependable role of conventional generation, which is complemented by intermittent renewable energy generation. With climate change ever-increasing priorities, the need to reduce fossil fuel usage in favor of Alternative Fuels and Resources (AFR) such as waste oils, mixtures of non-recycled plastics, paper, cardboard, used tires, biomass wastes, municipal solid waste, and even wastewater sludge becomes greater and greater. Meanwhile, traditional fuels used in cement rotary kilns include coal, petroleum coke, heavy low-quality fuel oil and natural gas. There are different reasons for co-processing AFR. These include: Circular economy, environmental concerns, the polluter pays and fuel costs savings.

This study aims to provide a critical and comparative presentation of co-processing AFR within the cement production and manufacturing process in Greece, Sweden and the Germany. Harnessing appropriate technology-mindset, getting reputation for fairness and more open thinking in the greek cement production industry could be tools towards minimizing on-site AFR, reducing environmental air pollution and impact.

Keywords: *Alternative Fuels and Resources, Alternative waste fuels*, *Cement industry, Circular economy, Environmental pollution, Municipal and industrial waste derived fuels.*

1. INTRODUCTION

The implementation of the legal framework for waste management – fulfilling the condition of conditionalities to finance new projects – also include the unreliable operation owing to the theft of recycling waste materials. The illegal detachment of recycling waste bins and removal of their material has been a problem in the evolution and operation of critical infrastructures, such as recycling waste material and transportation networks. Now days, the problem has become less acute as large enough quantities of recyclables are accumulated in sorting centers for recyclable materials (SCRM) due to sharp decline in prices related to recycling materials i.e. paper, cardboard and plastic bags, etc., and a break in international trade associated with exports to China.

In the context of the circular economy, domestic demand of recycling materials utilization remains low. Thus, the 35 greek SCRM are backed by the Hellenic Recovery Recycling Corporation (HERRCO) which subsidizes the sale of recyclable materials to make the SCRM units more sustainable. The increasing incidents, targeting the Extended Producer Responsibility (EPR) for packaging defined by the Waste European Directive (94/62/EC), need to be addressed not only by a more environmentally friendly packaging materials (viz. renewable, biodegradable, minimize packing weight and design principles, etc.), but also through adoption of co-processing Alternative Fuels and Resources (AFR) in the greek cement industry.

2. A BRIEF OULINE OF THE CEMENT PRODUCTION

2.1. Where is cement produced in Greece, Sweden and Germany

There are eight (8) integrated manufacturing facilities in Greece operated by three (3) companies – Titan Cement Company S.A, Aget-Heracles General Cement S.A. a subsidiary of LafargeHolcin and Halyps Cement S.A. a subsidiary of HeidelbergCement Group. Cementa A.B. also a subsidiary of HeidelbergCement Group is the only cement producer in Sweden with 2 plants in Slite – an island off the southeast coast – and in Skövde, in southern Sweden. With a mix of mid-size and large enterprises, the German cement industry consists of 22 companies and 53 plants.

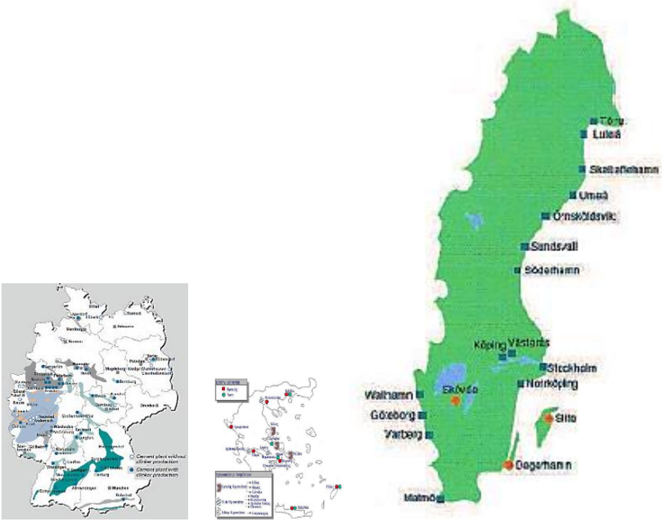

Figure 1. Location of integrated cement manufacturing sites (geographically comparable sizes).

3. CLOSING THE LOOP - GREENHOUSE GAS EMISSIONS AND OTHER POLLUTERS

Concrete is a long-lasting material, but it also enables co-processing and recycling during its production in Greece, Sweden and Germany, hence continuously looking into new applications to re-use AFR as materials for renewable energy generation.

3.1. Titan Company S.A

Titan Cement Company S.A. operating four (4) cement facilities clinker production in Greece have been using used tires, refinery sludge/sawdust, dry sewage sludge (DSS), agricultural waste/biomass (rice husk, paper pulp cotton seed), flexicoke as a refinery Refuse Derived Fuel (RDF) commencing from packaging waste and automotive shredder residue (ASR) since 2001. The use of alternative fuels in Kamari plant over the year 2014 were 85.500 tones, whereas at the year-end 2015 in total have been reached 62.000 tones. According to the company, in the course of the last five years, the substitution of non-renewable resources with alternative fuels has allowed the Titan Company S.A. to achieve a reduction of over 190.000 tons of CO_2 and 250.000 tons of carbon equivalent. Nevertheless, the company is also providing a cost-effective waste-management solution for the greek society in the safest and most widely tested method worldwide.

3.1.2. Operation & Quality Control working procedures

According to the website, Titan Cement Company S.A. is complying with the European standard EN 15359:2011 which defines the criteria for Solid Recovered Fuel (SRF)-specifications and classes. The company secured the use of closed storage & feeding unit, Bag filters, Selective Non-Catalytic Reduction (SNCR), New low-NOx Burners, on line analyzers, Continuous Emissions Monitoring System (CEMS) and quality control equipment.

3.1.3. Research & Development

The initiatives of Titan Cement Company S.A are based on innovative technologies and concepts. These include:

(A) Improving CO_2 footprint by participation in the WBCSD's Low Carbon Technology Partnerships Initiative (LCTPi) and collaborate with scientific institutions like the European Cement Research Academy (ECRA). Through these partnerships the research and develop of new technologies, methods and materials will help Titan Cement Company S.A. to reduce carbon footprint throughout the value chain, in line with the (LCTPi) and the Paris Agreement on climate change (COP21),

(B*)* Producing "Low Carbon Cement" where the low carbon cement is produced using less limestone and less fuels compared to conventional cements. This leads up to 30% reduction in CO_2 emissions during production, which is in line with Titan's steadfast commitment to reducing greenhouse gases,

(C) Introducing Artificial Intelligence**,** and

(D) Using Separation Technologies (STET) where STET is the global leader in industrial tribo-electrostatic separation offering its unique technology and services to customers in industries such as construction, mining, food & nutrition, and animal feed.

3.2. Aget-Heracles S.A. (LafargeHolcim)

The Aget-Heracles S.A. operates three (3) cement facilities in Greece, namely in Volos, Mylaki and Halkida. It is reported that about 20% of all fuel spent on clinker production during 2016/17 came from alternative waste fuels. **Figure 2** shows the alternative waste fuels given in percentages, according to the Aget-Heracles owned by the LafargeHolcim.

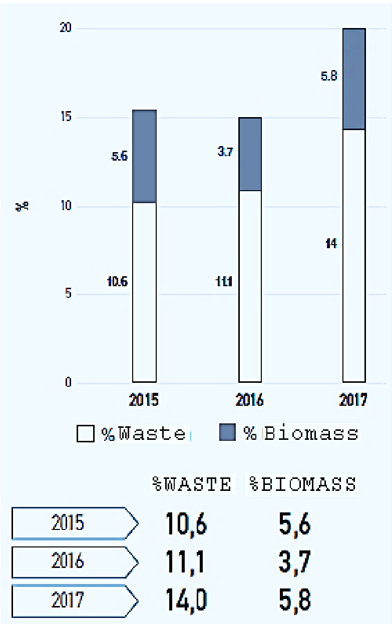

Figure 2. Alternative waste fuels according to their origins in the Aget-Heracles S.A.

3.2.1. Operation & Quality Control working procedures

The challenge when using alternative waste fuels in cement production is that the fuel must contain those properties that are important for the cement process; examples include the chemical composition, the moisture content of the material and its calorific value, but also how the biofuel can be handled at the factory or its incineration properties.

The cement manufacturing is a continuous process which includes the high temperature process of cement clinker production. Large quantities of raw materials and fuels enter in this process and on the other hand cement clinker and later cement, CO_2

emissions and smaller quantities of some other emission polluters exit as output. The process is also suitable for the use of selected wastes, which could be used as alternative fuels (viz. AFR), replacing other fossil sources. Wastes that are formed in the cement plant could be also used within cement production process.

In the attempt to build the "zero waste" society, cement plant in Volos can play an important role. This role should be balanced with procedures preventing negative impact on the environment. The use of waste should be in accordance with legislation and environmental permit. Discussions have been ongoing regarding how to balance the need for cement adopting the co-firing of SRF and RDF (e.g. 100.000-200.000 tons yearly) and working procedures, as well as protecting nature and the local community around the cement plant. A decision on this case has moved from the local level to the national level. A recent amendment for the Aget-Heracles S.A. due to the modification of environmental licensing has introduced additional conditions for the utilization of alternative fuels and secondary SRF/RDF fuels, which relate to the reception, storage and catering facilities of alternative waste fuels. Furthermore, stringent specifications required to comply with the European standard EN 15359:2011 (classification of RDF) and the European Standards EN 15442:2011 and EN 15443:2011 (classification of SRF) for sampling and analysis need be the adopted and maintained.

3.3. Halyps Cement S.A.

The Halyps company S.A. was set up in Aspropyrgos (Attica) in 1934. The company belonged to the Italcementi Group was acquired by HeidelbergCement in 2016. In Greece, the HeidelbergCement Group operate in the cement, concrete, and aggregates sectors through Halyps Cement S.A.

3.4. Cementa A.B.

Sweden has already spent decades decarbonizing its energy supply. In the 1970s, it started building a fleet of nuclear power reactors. In the 1990s, it introduced a carbon tax, which encouraged a move away from fossil fuels. In the 2000s, it started investing more heavily in renewable energy, especially biomass and wind. Since the cement production process has traditionally been driven by fossil fuels such as coal and petroleum coke, the production of cement generates large amounts of greenhouse gases, particularly CO_2. According to a Swedish study, on a global level, cement production accounts for approximately 3-5% of all anthropogenic CO_2 emissions.

In 2007, the emissions from Cementa's Slite plant constituted about 2% of all CO_2 emissions in Sweden, which puts the plant among the top 5 largest Swedish emitters of carbon dioxide. However, some of the CO_2 emissions from the production process are offset during the life cycle of the end product. Concrete – cement mixed with aggregates such as gravel, sand or crushed stone – actually absorbs CO_2 in a slow reversed version of the separation of calcium oxide from limestone. Furthermore, in order to reduce the plant's CO_2 emissions and to reduce fuel costs, Cementa A.B. has fulfilled the ambition to increase the share of alternative fuels in its fuel mix. Since 2008, about 30% of the fuel input at the Slite plant consisted of alternative fuels, and Cementa's goal was that this share could increase continuously and that within five years, alternative fuels would dominate the fuel mix (see **Figure 3**).

The term "alternative fuels" is used by Cementa A.B. for fuels based on biomass and different forms of waste (e.g. AFR). Examples of alternative fuels are discarded car tires, municipal solid waste, meat production residues, and different forms of wood and paper residues. The waste used in Slite comes both from Gotland, mainland Sweden, and Finland. About 20% of the waste is imported, e.g. in the form of RDF pellets from the Netherlands and Ireland. The high and stabile temperatures of the furnaces used in the production process makes it viable to safely combust refuse. Furthermore, all ashes produced from the combustion are recycled as raw material in the finished cement.

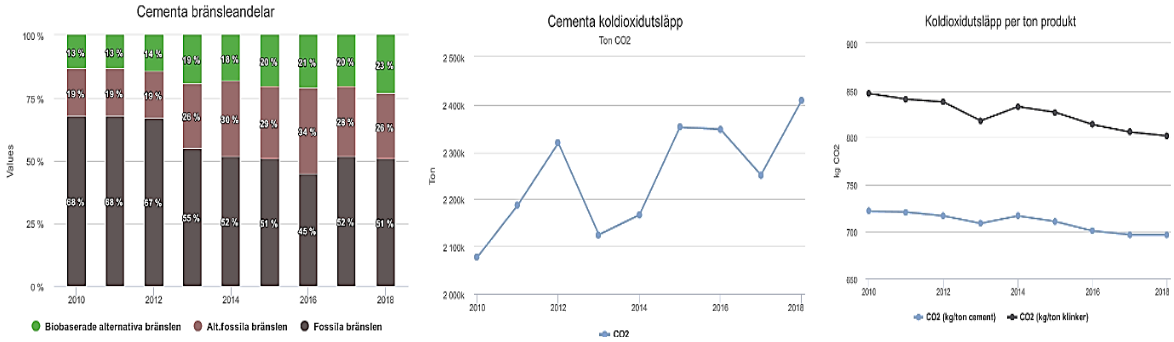

Figure 3. Historical (2010-2018) fuel mix and by-product CO_2 emissions at Cementa A.B.

The combustion of municipal solid wastes (MSW) has very significant benefits in reducing the volume of waste materials and producing energy. However, combustion processes produce emissions, which must be below the Best Practical Means (BPM) specified legislative limits. Several wastes, such as used tires, Recovered Fuel Oil (RFO), solvents and paints, and meat meal, etc., have been successfully combusted in cement kilns, up to 20% w/w, while retaining emission standards well below legislative limits. In the case of MSW the introduction of large amounts of MSW into cement kilns is not practical because the additional kiln volume required is too great, the large amounts of ash generated will affect the cement clinker quality, and it would be difficult to sustain the required very high clinkering temperature of 1500 °C with large quantities of low calorific value MSW.

3.4.1. Operation & Quality Control working procedures

Strict control of composition, caloric value, process parameters, products and emissions have been assured, see also Stockholm Convention on Persistent Organic Pollutants. A world-first project “Northern Lights” for carbon capture within the cement industry has been signed between HeidelbergCement (Cementa A.B.) and Equinor (a Norwegian state oil company) this year. Since 2013, four technologies have been tested with good results. At the plant of Degerhamn (Sweden) a project is run to evaluate the potential of letting algae consume carbon dioxide that is generated from the cement production. Another feasibility study with the aim of establishing a framework for a full-scale carbon capture facility was entry since 2016. This project and the study are government funded and are managed in cooperation with the European Cement Research Academy (ECRA).

3.4.2. Living next to the Cementa A.B.

The industrial operations that are part of Cementa’s business can be a source of disturbances in terms of noise and vibrations particularly to quarries, cement plants and loading operations at the harbors. The company work proactively to reduce noise levels through measures such as erecting sound barriers, building in equipment and establishing clear agreements with shipping agents.

An open dialogue with the neighbors is important. Cementa A.B. constantly communicate with the local community around the cement plants through meetings, newsletters, and online information about the status of emissions and ongoing improvement projects. Blasting in quarries that are close to residential areas requires special attention. The company strive to inform local communities regularly about its planned activities and perform blasts at regular times.

3.5. HeidelbergCement Group

Cement clinker burning uses up most of the fuel energy consumed in cement manufacture. To a lesser extent thermal energy is also used for drying raw materials and other major cement constituents, such as granulated blast furnace slag. Since the mid-

1970ies, the traditional fuels of the German cement industry have been coal and lignite and, on a smaller scale, also heavy fuel oil. A significant portion of coal has been replaced by petcoke since the 1990ies. Petcoke is a coal-like fraction of mineral oil generated in crude oil processing. In addition to that, light and heavy fuel oil and gas are used for kiln start-up and drying processes. Apart from fossil fuels, the use of alternative fuels in the clinker burning process is gaining in importance nowadays. Alternative fuels accounted 67,5 % of the total fuel energy demand of the German cement industry in 2018. **Table 1** lists the alternative fuels utilized and their average calorific values. The development of the specific energy consumption in the cement industry is shown in **Figure 4**.

3.5.1. Operation & Quality Control working procedures

Emissions from cement works can be determined both by continuous and discontinuous measuring methods, which are described in corresponding VDI guidelines and DIN standards (**Table 2**). Continuous measurement is primarily used for dust, NOx, SO_2, Hg and NH_3 as well as more and more total organic carbon (TOC), while the remaining parameters relevant to ambient pollution legislation are usually determined discontinuously by individual measurements. Energy-related emissions are generated both directly through fuel combustion and indirectly through the use of electrical power, see **Figure 4**.

Table 1. Used quantity and average calorific value of alternative fuels in 2018.

Alternative Fuel	1000 t	MJ/kg
Waste tires	196	28
Waste oil	70	30
Fractions of industrial and commercial waste		
Pulp, paper and cardboard	76	5
Plastics	758	23
Packaging	-	-
Wastes from the textile industry	6	30
Others	1136	22
Meat and bone meal and animal fat	164	18
Mixed fractions of municipal waste	280	18
Waste wood	1	14
Solvents	135	25
Fuller's earth	-	-
Sewage sludge	633	2
Others, such as:	146	4
Oil sludge		
Organic distillation residues		

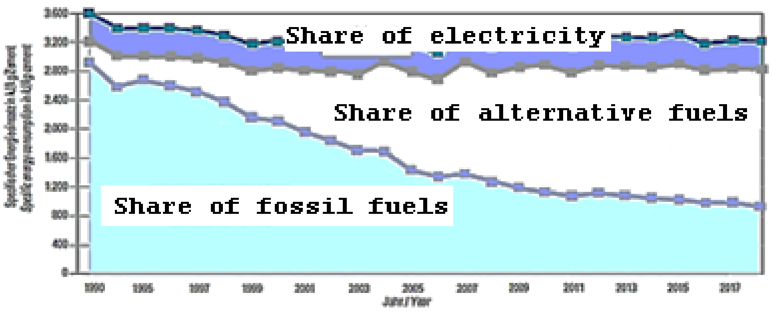

Figure 4. Development of the specific fuel energy consumption.

The emission measurements at the rotary kiln plants of the German cement industry are required by law. The emissions measured continuously are converted to annual averages.

In the case of emissions measured discontinuously, the values are derived from the respective individual measurements.

Table 2. Emission measuring methods.

Object of measurement	Standard, guideline
Total dust	DIN EN 13284-1
Heavy metals	DIN EN 13211, 14385
Sulphur oxides	DIN EN 14791
Nitrogen oxides	DIN EN 14792
Carbon monoxide	DIN EN 15058
Gaseous inorganic chlorine compounds	DIN EN 1911, Teil 1-3
Gaseous inorganic fluorine compounds	VDI 2470, Blatt 1
Dioxins, furans	
Sampling	DIN EN 1948, Teil 1
Analysis	DIN EN 1948, Teil 2-3
Polycyclic aromatic hydrocarbons	DIN EN 1948 Teil 1 VDI 3874
Polychlorinated biphenyls	DIN EN 1948, Teil 4
Total gaseous organic carbon	DIN EN 12619
Benzene, Toluene, Ethyl benzene, Xylene	DIN EN 13649

3.5.2. Greenhouse gases/carbon dioxide (CO_2)

Figure 5 depicts the development of direct CO_2 emissions. On January 1, 2005 a trading system for CO_2 emissions was introduced in the EU. Direct CO_2 emissions from the combustion of all fuels – except biomass and decarbonation of limestone are covered by this trading system.

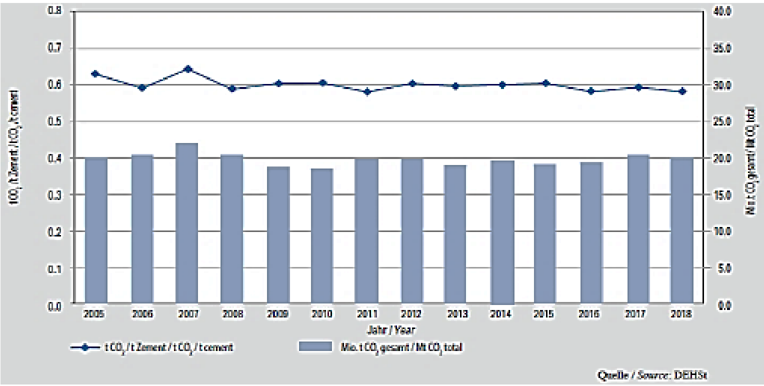

Figure 5. Direct CO_2 emissions by the German cement industry.

4. CONCLUSIONS

Utilization of fossil fuels, which represents an increasing environmental risk, can be made more environmentally friendly by adding Alternative Fuels and Resources (AFR) – as concluded based on this study. In search of less polluting ways of energy production, increasing the amount of AFR as a source of raw materials offers a good way to reduce notorious carbon dioxide (CO_2) emissions and waste. There are two main environmental concerns related to AFR. First, flue gases contain various pollutants emitted into the atmosphere in addition to carbon dioxide and, secondly, ash is produced during combustion. However, the quality of the ash is suitable for “re-use" as a raw material for production of “green” cement. Nevertheless, carbon capture and utilization technologies – these are topics of the future, which the heat-power engineering will deal with in the short term.

Many years of experience in Northern Europe have shown that utilize AFR within cement plants is both ecologically and economically justified. The companies that choose to implement sound pollution prevention methods are likely to enjoy positive ROI and better business than those that do not. It's pretty common these days for businesses to develop plans focused on corporate social responsibility (CSR) and sustainability. Therefore, the technological developments that are driving innovation, efficiency and social acceptance, when trying to reduce waste and operation costs can be beneficial.

Greek data on the current production and use of true AFR are limitedly presented. Moreover, a National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants for Greece is still pending after 2006. For future studies, more greek data should be accessed for AFR in order to have more realistic approach. The concept of communication with the local communities is not yet applied sufficiently by stakeholders. There is a potential for the greek cement industry to minimize emissions by replacement of conventional fossil fuels with AFR such as SRF having an acceptable bulk density.

Since climate targets, circular economy, “polluter pays” and environmental concerns are constantly becoming stricter, Greece is facing circumstances where the greek cement companies are encouraged to harness appropriate technology-mindset, new ways of innovative thinking and doing. The new Innovation Fund (viz. Green Deal) set up by the EC, with € 10 billion in funding over the next decade as a source of revenue for the EU Emissions Trading System (ETS), is an essential opportunity for the Greek industrial and business world to evolve, implementing innovative "green" technologies.

5. REFERENCES

HeidelbergCement Northern Europe, http://www.cementa.se.

Zahlen und Daten – Zementindustrie in Deutschland 2019, Verein Deutscher Zementwerke e. V., Duesseldorf.

Halyps Cement S.A., http://www.halyps.gr

Verminderung der CO_2 Emission, Umfrage zum Monitoring-Bericht 2012, Verein Deutscher Zementwerke e. V., Duesseldorf.

Aget-Heracles General Cement S.A., http://www.lafarge.gr.

Klein H., Hoenig V., Model calculations of the fuel energy requirement for the clinker burning process, Cement International 3/2006 Vol. 4.

Titan Cement Company S.A., http://www.titan.gr.

Stockholm Convention on Persistent Organic Pollutants (POPs), http://www.pops.int/Implementation/NationalImplementationPlans/NIPTransmission/tabid/253/Default.aspx.

Taralas G. and Rydén A., 2015. The landscape of municipal waste management in Greece, S.p.N.p. Scandinavian Proxima Nature Project & Co, Maroussi, Athens, Greece.

Doukas E., Adamopoulou Th., Pantazis G., Gklinos P., Rydén A., Taralas G., H. Neratzis H., 2017. Municipal solid waste contracts in Greece receiving EU funding (in Greek), In: EEDSA and ISWA (eds.), Proceedings of the 5th International Conference HSWMA on Solid Waste Management & Its Contribution to Circular Economy, 2017, 14-15 December, Athens, Greece.

Taralas G., Kontominas M., 2009. Applications of embedded renewable energy production from industrial and municipal solid waste (MSW) in Greece: Computational fluid dynamics for circulating fluidized bed (CFB)–gasifiers, In: EEDSA (ed.), Proceedings of the 3th International Conference on Solid Waste Management : Towards a Zero Waste Society, 2009, 30-31 October, Athens, Greece.

HeidelbergCement Group, http://www.heidelbergcement.com.