WP5.2 Screening of BATs, BREFs and BEPs

STUDY ON BEST PRACTICES FOR THE WASTE-TO-ENERGY PROCESS IN THE MEDITERRANEAN CEMENT SECTOR TO AVOID OR MINIMIZE ENVIRONMENTAL PROBLEMS (FOOTPRINT)

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Version	Document Title	Author	Review and Clearance
1	STUDY ON BEST PRACTICES FOR THE WASTE-TO-ENERGY PROCESS IN THE MEDITERRANEAN CEMENT SECTOR TO AVOID OR MINIMIZE ENVIRONMENTAL PROBLEMS (FOOTPRINT)	Manuel Soriano Covadonga González	Michael Scoullos

THE SWIM AND H2020 SUPPORT MECHANISM PROJECT (2016-2019)

The SWIM-H2020 SM is a Regional Technical Support Program that includes the following Partner Countries (PCs): Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, [Syria] and Tunisia. However, in order to ensure the coherence and effectiveness of Union financing or to foster regional co-operation, eligibility of specific actions will be extended to the Western Balkan countries (Albania, Bosnia Herzegovina and Montenegro), Turkey and Mauritania. The Program is funded by the European Neighbourhood Instrument (ENI) South/Environment. It ensures the continuation of EU's regional support to ENP South countries in the fields of water management, marine pollution prevention and adds value to other important EU-funded regional programs in related fields, in particular the SWITCH-Med program, and the Clima South program, as well as to projects under the EU bilateral programming, where environment and water are identified as priority sectors for the EU co-operation. It complements and provides operational partnerships and links with the projects labelled by the Union for the Mediterranean, project preparation facilities in particular MESHIP phase II and with the next phase of the ENPI-SEIS project on environmental information systems, whereas its work plan will be coherent with, and supportive of, the Barcelona Convention and its Mediterranean Action Plan.

The overall objective of the Program is to contribute to reduced marine pollution and a more sustainable use of scarce water resources. The Technical Assistance services are grouped in 6 work packages: WP1. Expert facility, WP2. Peer-to-peer experience sharing and dialogue, WP3. Training activities, WP4. Communication and visibility, WP5. Capitalizing the lessons learnt, good practices and success stories and WP6. Support activities.

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Disclaimer:

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ABBREVIATIONS

AF	Alternative Fuels
AFR	Alternative Fuels and Raw Materials or “Alternative Fuels”
BAT	Best Available Techniques
BAT-AEL	Best Available Techniques Associated Emission Levels
BEP	Best Environmental Practices
BM	Business Model
BREF	European Commission Reference Document on Best Available Techniques
CAPEX	Capital Expenditures
CAPMAS	Central Agency for Public Mobilization and Statistics
CDW	Construction and Demolition Waste
CF	Clinker Factor
CPCB	Central Pollution Control Board
CSI	Cement Sustainability Initiative
CSR	Corporate Social Responsibility
DSS	Dried Sewage Sludge
EC	European Community
EE	Environmental Education
EEA	European Environmental Agency
EIA	Environmental Impact Assessment
EIPPCB	European Integrated Pollution Prevention and Control Bureau
ELV	Emission Limit Value
EMR	Emission Monitoring and Reporting
ENP	European Neighbouring Policy
ESD	Education for Sustainable Development
ESM	Environmental Sound Management
EPA	Environmental Protection Agency
EU	European Union
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
GIZ	Gesellschaft für Internationale Zusammenarbeit
GNR	Getting the Number Right

HW	Hazardous Wastes
IED	Industrial Emission Directive
IPPC	Integrated Pollution Prevention Control
JRC	Joint Research Centre
LCA	Life Cycle Analysis
MoE	Ministry of Environment
MRV	Monitoring, Reporting and Verification
MSESD	Mediterranean Strategy on Education for Sustainable Development
MSW	Municipal Solid Waste
NGO	Non-Governmental Organization
OH&S	Occupational Health and Safety
OPEX	Operational Expenditures
PCDD/F	Polychlorinated dibenzo dioxins and furans
POPs	Persistent Organic Pollutants
ppb	Parts per billion
ppm	Parts per million
PCs	Partner Countries
PPP	Public Private Partnership
RDF	Refuse Derived Fuels
SCP	Sustainable Consumption and Production
SEM	Sound Environmental Management
SNCR	Selective Non-Catalytic Reduction
SWM	Solid Waste Management
TDF	Tire Derived Fuel
TOC	Total Organic Carbon
TSR	Thermal Substitution Rate
UNEP	United Nations Environment Program
VOC	Volatile Organic Compounds
WBCSD	World Business Council for Sustainable Development
WMRA	Waste Management Regulatory Authority
WtE	Waste to Energy
WWPT	Wastewater Treatment Plant

EXECUTIVE SUMMARY

In a world with rapidly increasing population and urbanisation, cement production and use, as well as, generation of wastes follow parallel upward going trends.

Wastes represent a serious risk for the health of our planet and their proper management is a big challenge for authorities, companies and the global community. On the other hand, waste are valuable resources that the society cannot afford any longer to dispose in a world continually growing up in population and standard of living, but decreasing in natural resources.

A possible solution to this imbalanced situation could be based on three principles:

- Eco-efficient production processes able to produce more with less resources' consumption and less emission and wastes' generation. This is the vision of Best Available Techniques (BATs).
- Responsible consumption behaviour in society. This is the role of authorities, enterprises and individuals, through education and awareness, and the society as a whole composed of responsible citizens.
- Sustainable waste management able to transform wastes into recovered resources suitable to be used in the production processes. This is the aim of Circular Economy and the responsibility of institutions, companies and citizens, together.

The role of the cement industry in waste management

The cement industry contributes notably to improve the standard of living of the society by means of construction materials but, on the other hand, it is a big consumer of natural resources and an important emitter of greenhouse gases worldwide. Nevertheless, the cement industry is deeply committed to produce cement according to more eco-efficient way, while it contributes to solve the waste management problem of the society. The result is a cement industry, operating according to the Sustainable Development principles.

The Environmental commitment of the EU and its neighbourhood policy

The EU keeps a clear leadership position on environmental matters and specifically in both climate change prevention and circular economy. Moreover, it is committed to help neighbouring countries in adopting its Best Environmental Practices, in order to prevent pollution especially in the Mediterranean.

Projects like "The SWIM-Horizon 2020 SM" are examples of this commitment on the matter. The purpose of the present report, requested by the Sustainable Production and Consumption Regional Activity Center (SCP-RAC) of the UN Environment/Mediterranean Action Plan as a partner of the SWIM H2020 SM project, is to promote the use of waste as a source of energy for the Mediterranean cement industry, in order to avoid or minimize environmental issues.

European Best Environmental Practices

European regulations on pollution prevention and clean production are an example to be followed by any country interested in implementing a sustainable development model. Furthermore, European Best

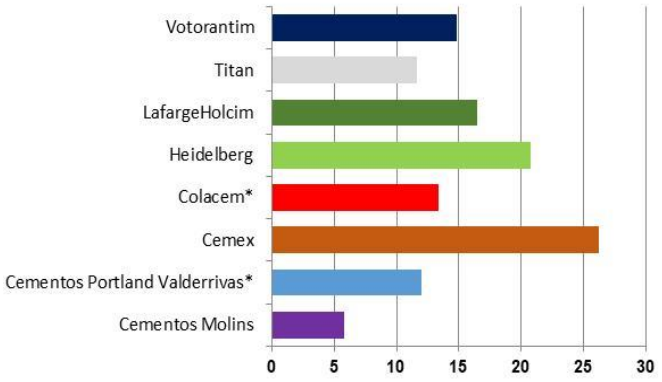
Environmental Practices are also of great interest. So, an updated summary of European regulation and best practices in the European Cement industry have been considered as orientation guidelines for the targeted Partner Countries (PCs).

Present situation on waste management and cement production in the target countries

A fundamental advantage of the cement industry is the employment of very high temperatures in its productive process which allow the thermal destruction of virtually all types of organic molecules/pollutants, while the resulting ash/mineral residue could be incorporated in the produced cement. This is obtained through properly controlled co-processing. In fact, co-processing is the use of wastes in cement production, a combined operation composed of energy recovery and material recycling. While incineration and landfilling are considered disposal operations, properly controlled co-processing can provide a practical, cost-effective and environmentally preferable option. In general, co-processing of waste in resource-intensive processes can be an important element of a more sustainable system of managing raw materials and energy.

Based on available documentation and personal interviews, some general information on the cement sector and waste management situation has been obtained. Main conclusions are:

- Co-processing rate in the region is low due to different factors related to regulations, law enforcement and social culture, but principally to waste management issues.
- There is a strong cement industry in the region and the main global cement producers are operating there, so the corporate capacity and the technical know-how to develop waste co-processing at high level are already present.



Thermal substitution rate (%) with alternative fuels in some global cement players

- Inadequate waste management and its corresponding environmental impact is in some countries a big issue and it is, for sure, the main barrier to Alternative Fuel (AF) availability and co-processing development. Waste management strategies are not clear in general and there are misconceptions controversy between landfilling and incineration in some countries.
- Low enforcement in those countries with environmental regulations is a big problem. Restrictions concerning waste import for recovery are an important barrier for those local cement plants that are ready to develop the co-processing activity, but they cannot get locally enough Alternative Fuel.
- Social awareness is still low in many countries and the position of certain non-governmental organisations (NGOs) may be especially aggressive against co-processing, as it happens in Lebanon.

Recommendations

Based on country situation and guidelines, either from the EU or the cement industry, a summary of recommendations has been submitted. Countries have been grouped according to regional criteria, Egypt and Turkey are grouped as a separate category due to their high volume and significance both in cement and waste production and generation.

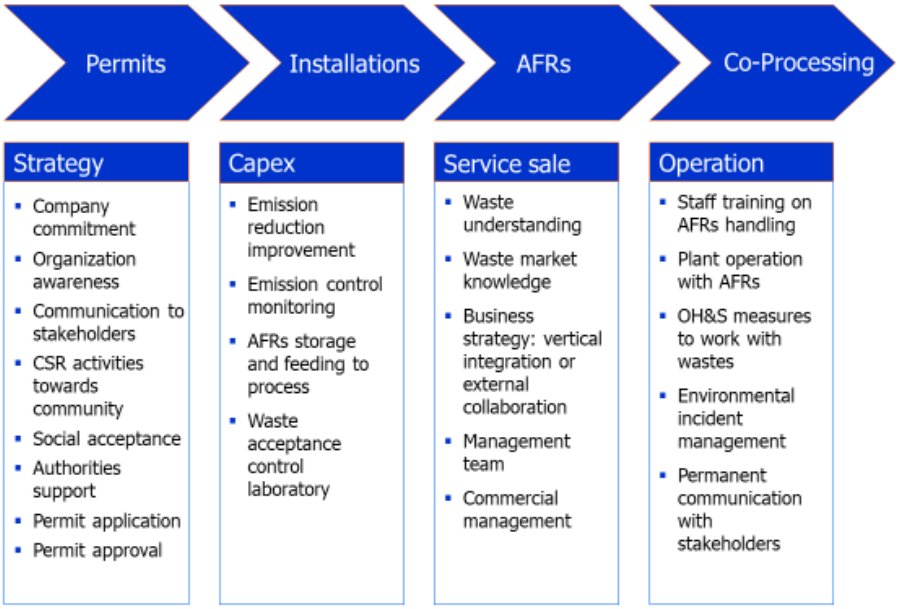
- Northern African countries: Algeria, Mauritania, Morocco and Tunisia
- Middle Eastern countries: Israel, Jordan, Lebanon and Palestine
- Balkan countries: Albania, Bosnia, Herzegovina and Montenegro
- Big countries: Egypt and Turkey.

Each country has its own situation, taking into account that the targeted group includes very big and very small countries, important cement producers and countries which do not have any integrated cement production plants. Nevertheless, there are some common recommendations useful for all of them:

- The need of implementing an environmental regulation framework with an integrated approach based on accepted international criteria, like pollution prevention, circular and green economy, addressed to reach a Sustainable Development model.
- To guarantee the enforcement of existing regulations with inspections, incentive policies and penalty measures is essential.
- The import of waste for recovery treatments, such as Alternative Fuel for the cement industry, would have a positive effect on co-processing development but, furthermore, to create social awareness on circular economy principles.
- To create awareness by means of education and promote social participation in strategies, plans and projects is still a general requirement despite the valuable efforts already accomplished by some countries and SWIM-H2020 SM interventions/activities. This condition is a requirement to develop the Waste to Energy process and specially for developing co-processing in the cement industry.
- To set up the proper priority to Municipal Solid Waste (MSW) management and adopt rapid and reasonable initiatives in this field with the participation of the private sector that can provide technological innovation and economic resources as well in, doing so, an Environmental Sector Management (ESM) for Municipal Solid Waste should be consolidated and a permanent source of Alternative Fuel for the cement Industry should become available.
- Focus on additional initiatives to solve some local problems with agriculture wastes, like many olive oil production wastes that have a big polluting capacity and could be solved within the Waste to Energy approach.

The roadmap for waste co-processing in the cement industry

While the waste co-processing depends on external factors outside the cement industry's control, its success depends very much on the cement company strategy, assuming the co-processing as a fundamental part of the sustainable way for manufacturing cement. A recommended cement company roadmap to develop co-processing within the business strategy is shown next:



Cement company roadmap to develop co-processing

1 GENERAL INTRODUCTION

1.1 BACKGROUND

The **SWIM-H2020 SM Project** (Sustainable Water Integrated Management and Horizon 2020 Support Mechanism 2016-2019) funded by the European Union **aims to contribute to reduced marine pollution and a sustainable use of scarce water resources in the target countries.** The Project is the continuation and merging of two successful previous EU-funded service contracts, Horizon 2020 Capacity Building/Mediterranean Environment Programme (H2020 CB/MEP) (2009-2014) and the Sustainable Water Integrated Management Support Mechanism (SWIM SM) (2010-2015).

The SWIM-Horizon 2020 SM will provide tailored and targeted support to authorities and other stakeholders of the Partner Countries in order to tackle the reduction of industrial emissions, municipal waste and urban wastewater to the Mediterranean Sea and ensure the sustainable use of water resources.

The RAC/SCP is a centre for international cooperation with the Mediterranean countries on development and innovation in the production sector and civil society, based on more sustainable consumption and production models.

The RAC/SCP develops its activity under the Mediterranean Action Plan (MAP) for the protection and development of the Mediterranean basin, an organization belonging to United Nations Environment Programme through the Barcelona Convention.

The Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean, originally the Convention for the Protection of the Mediterranean Sea against Pollution, is a regional conference which signed parts are: Albania, Algeria, Bosnia Herzegovina, Croatia, Cyprus, Egypt, European Union, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Monaco, Montenegro, Morocco, Slovenia, Spain, Syria, Tunisia and Turkey.

The RAC/SCP is currently a partner of the Sustainable Water Integrated Management and Horizon 2020 Support Mechanism (SWIM H2020 SM Project) a Regional Technical Support Program that includes the following partner countries: Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Palestine and Tunisia. However, in order to ensure the coherence and effectiveness of Union financing or to foster regional co-operation, eligibility of specific actions will be extended to western Balkan countries (Albania, Bosnia Herzegovina, and Montenegro), Turkey and Mauritania.

ENP south countries have shown continuous interest to adapt and replicate the EU Industrial Emissions Directive and IPPC-related approaches in order to reduce the impacts of their most polluting industrial activities. So compiling the existing regulations and updating the information for key sectors is necessary to continue supporting ENP south countries in managing their most polluting industries. However, in doing so, it is crucial that BATs and BEPs incorporate circular economy measures in order to include life-cycle thinking at the core of the pollution prevention measures and strategies of target sectors.

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1.2 SCOPE OF THE WORK

The purpose of the present work is to produce a technical study compiling the best practices for the waste-to-energy process in order to avoid o minimize environmental issues in the cement sector in the Mediterranean, according to RAC/SCP document Terms of Reference for the selection of an expert in the cement sector to produce a study on best practices for the waste-to-energy process in order to avoid or minimize environmental issues in the cement sector and the annex Terms of reference for Non-Key Experts to support the Screening of BATs, BREFs and BEPs (WP5.2).

The technical study includes Cement BATs, BREFs and BEP complemented with Circular Economy measures. The report also includes a general panorama of the cement sector in the selected countries in geographic and economic terms as well as a description of the main industrial processes and the by-product and wastes generated by them.

Although the cement industry can use wastes, both as fuels and raw materials, the present study is only focused to the waste-to energy process, that means the use of wastes as alternative fuels to the traditional fossil fuels used by the cement industry, primarily coal and petcoke.

1.3 WORKING METHODOLOGY

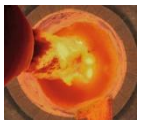
To produce the present study the authors have followed the canvas business model and have worked according to the following methodology in order to get the information to build and deploy it:

- Collection of relevant information on the cement sector and waste management on the Mediterranean. Different sources such as cement associations, public bodies and so on have been used to collect this information.
- Analyse of the existing European legislation on Circular Economy, waste management, industrial emissions, cement BATs and BREFs.
- Collection and analysis of specific information on waste co-processing in cement kilns issued by leader cement companies, sectorial associations, or recognized organisations as World Business Council for Sustainable Development.
- Interviews with professional representatives belonging to Public Administrations, cement producer associations, waste management associations, cement, waste management and engineering companies and NGOs.

KEY PARTNERS

1) **Waste producers** (industries)
2) **Waste management companies** (waste collectors who need a final treatment to destroy wastes)
3) **Logistic companies** (special transport to bring wastes to the plant)
4) **Administration** (they stablish the legal framework)
5) **Neighbours** (understand and support the waste co-processing activity in the plant)
6) **NGO's** (support to waste co-processing activity in general)
7) **Associations** (associations representing any activity producing any specific waste. Ex: tyres).
8) **Media** (press, TV, radio, social media, etc.)

KEY ACTIVITIES



1) **Guarantee legal compliance** (concerning emission limits, retention basins, logistics, etc.)
2) **Negotiations with authorities** (to obtain the permits is a must)
3) **Awareness campaigns** (get the support of the stakeholders)
4) **Environmental control devices implemented**
5) **Facilities engineering and maintenance**

KEY RESOURCES

1) **Hazardous and non hazardous wastes** (AFR to substitute traditional fuels)
2) **Co-processing permits** (mandatory to develop the activity).
3) **Co-processing facilities** (for solids, liquids… wastes are not fed directly in the kiln)

VALUE PROPOSITION

1) **Providing a regular waste management service** (plant is working nearly 365 d/y, 24h/d)
2) **Reduction of waste landfilling** (cement plants are the alternative to destroy wastes and lengthen the life of landfills)
3) **CO_2 emissions reduction** (coprocessing of biomass wastes and others with lower CO2 emissions than traditional fuels)
4) **Environmentally safe treatment** (kiln temperatures up to 2000 ºC guarantee the destruction of all potential dangerous compounds)

CUSTOMER RELATIONSHIPS

1) **Cross-side network effects** (relationships between all customer segments)
2) **Trust oriented** (wastes are treated and destroyed with all the guarantees)
3) **Waste management service 100% guaranteed** (even if the plant is not working an alternative solution will be given to the wastes' producer).

CHANNELS

1) **Field sales** (direct sales force)
2) **Cement companies website** (promotion of waste co-processing activities)
3) **Registry of authorized waste managers** (inscription in the hazardous and non hazardous wastes registers)

CUSTOMER SEGMENTS

1) **Industry** (large, medium and small companies producing hazardous and non hazardous wastes)
2) **Waste management companies** (they collect wastes from different producers and use the cement plant service to eliminate them)
3) **Farmers and agriculture** (main biomass wastes' producers)
4) **Other cement companies** (during the plant shutdown, wastes can be derived to other authorized cement companies)
5) **Municipalities** (cement plants are an alternative to municipal waste incineration and disposal)

COST STRUCTURE

1) **Workforce** (salaries of the employees)
2) **Logistic cost to collect wastes and bring them to the cement plant** (either own or subcontracted transport)
3) **Wastes conditioning as alternative fuels** (some wastes need an specific physical treatment before being fed to the kiln)
4) **Awareness campaigns and lobby activities on waste co-processing**

REVENUE STREAMS

1) **Waste management business** (the cement plant is offering a waste management service; revenues come either from wastes' income or a lower price compared to traditional fuels)
2) **CO2 emissions savings** (waste co-processing, specially, biomass wastes, involves a reduction of CO_2 emissions, which means CO_2 allowances' saving)

2 THE CEMENT MANUFACTURING PROCESS AND THE WASTE CO-PROCESSING IN THE CEMENT INDUSTRY

2.1 THE CEMENT MANUFACTURING PROCESS

Cement is one of the most used industrial products and contributes notably to the sustainable development, providing solutions for housing and infrastructures that contribute to improve the life level and the wellbeing of society. Nevertheless, as any other industrial activity, it generates environmental impacts as energy and virgin mineral material consumption, GHG and other atmospheric contaminant emissions, noise or visual aesthetic impact. In fact, cement manufacturing can be done in a much more sustainable way if linked with recycling and waste to energy approaches The main benefits, are less consumption of energy and natural resources and less GHG emissions. Furthermore, cement industry can play an important role as provider of a sound environmental solution for local waste management.

Cement is a fine powdery substance that acts as a hydraulic binder. It is the key element for the construction industry where it is used in two different ways, as concrete or as mortar.

Concrete is a mixture of cement, water, aggregates that, thanks to the special binding properties of cement, become rapidly in a very resilient and durable material that can bear heavy loads and resist extreme environmental conditions. Most of the cement production is used to produce concrete. Mortar is cement mixed with water, lime and sand.

A wholly integrated cement manufacturing process, as shown in Figure 1 is divided in three parts: **a mining activity** for getting and prepare raw materials, **a chemical process** to produce the clinker and **a grinding stage** to get cement as final product.

Raw materials necessary for the cement industry are natural minerals that must be obtained through mining activities in quarries out of the cement plant premises. Limestone, marl and clay are the main minerals used, although small quantities of other minerals can be used as a source for iron or aluminium.

Clinker is an intermediate industrial substance and the main constituent of cement. It is produced by means of a chemical reaction at high temperature in a kiln from calcium carbonate and other materials able to provide silicon, aluminium and iron necessary to get the proper mix of silicates that compose clinker. To get the needed reaction temperature in raw materials an important volume of fuels is used to get a flame temperature up to 2000°C, which heats raw materials to 1,450°C necessary to transform original substances into clinker. During this process, calcium carbonate (limestone) is transformed into calcium oxide (lime), which then reacts with the other constituents from the raw material to form new minerals, collectively called clinker. This material is rapidly cooled to a temperature of 100 - 200°C.

Cement is the final commercial product of the cement industry and is produced from clinker, gypsum and other materials in a grinding process.

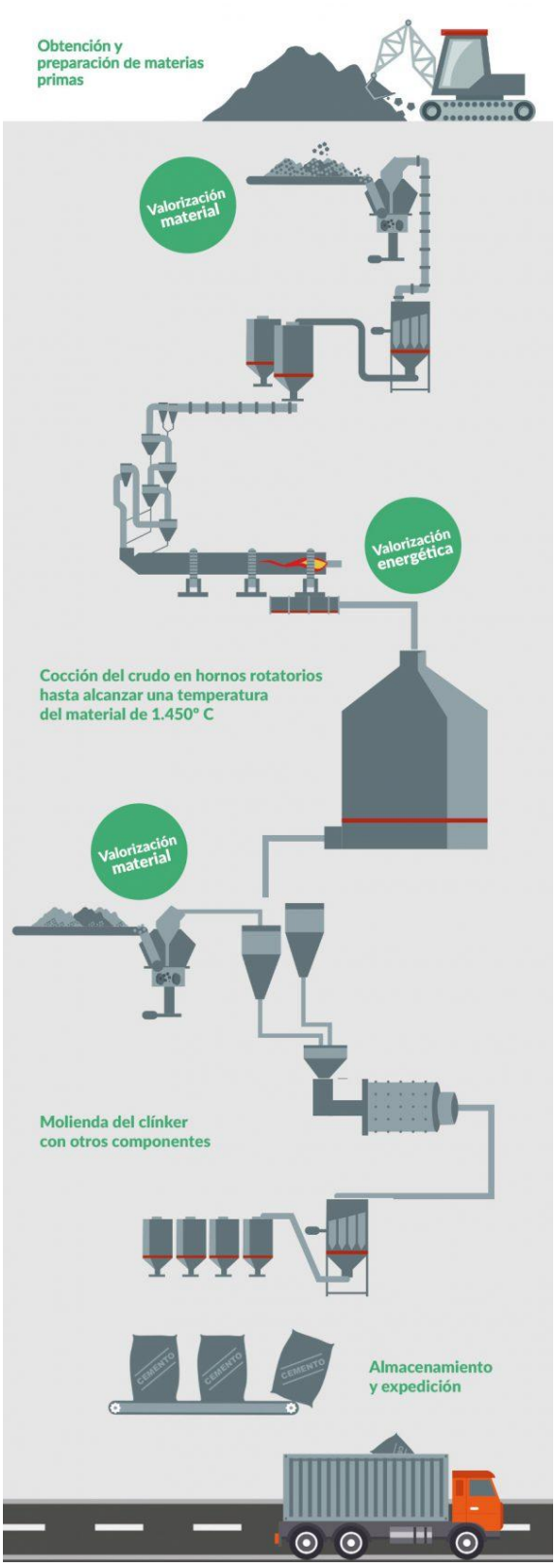


FIGURE 1. CEMENT MANUFACTURING PRODUCTION PROCESS SOURCE: FUNDACIÓN CEMA.

According to Cembureau (European Cement Association), the whole cement production process includes several steps from the mineral raw materials extraction to the final product storage ready for expedition.

Quarrying raw materials

Raw materials needed for cement manufacturing like limestone, marl or chalk, are extracted from quarries, providing calcium carbonate ($CaCO_3$). Very small amounts of materials such as iron ore, bauxite, shale, clay or sand may be needed to provide additional mineral components, necessary to produce the clinker, essentially iron oxide (Fe_2O_3), alumina (Al_2O_3) and silica (SiO_2).

Crushing

Quarried raw materials are transported to primary/secondary crushers and broken into small pieces.

Raw meal grinding

After crushing, the raw materials are mixed and milled together to produce 'raw meal' that is stored in the raw meal silos. To ensure high cement quality, the chemistry of the raw materials and the subsequent raw meal is very carefully monitored and controlled.

Preheating

Raw meal is fed to kiln system at the upper part of the cyclones tower where a heat interchange with hot exhaust gases coming from the kiln happens. A preheater consists of a series of cyclones through which the raw meal passes down by swirling hot flue gases in the opposite direction of the material flow. In these cyclones, a thermal interchange gas-solid happens and heat is transferred from the hot flue gases to the raw meal with the benefits of energy recovery and better process efficiency and thus less fuel consumption. The more cyclones stages have the system the higher is the preheater efficiency. New efficient plants have up to six stages of cyclones.

Precalcining

Calcination is the transformation of limestone into lime at high temperature. In modern dry process plants, this reaction partially takes place in a 'precalciner' -a combustion chamber at the bottom of the preheater above the kiln entrance- and the rest in the kiln itself. The chemical decomposition of limestone is typically responsible of 60% of total CO_2 emissions of the cement manufacturing process. Fuel combustion generates the rest of the CO_2 emissions.

Clinker production in the rotary kiln

Precalcined meal then enters the rotary kiln at the colder end of it with a temperature of around 1000°C. In the opposite end of the kiln several type of fuels - such as coal, petroleum coke, gas, oil and alternative fuels - are fired directly into the rotary kiln at up to 2000°C to ensure that the raw materials reach temperatures of up to 1,450°C. The kiln is a brick-lined steel tube (3-5 metres diameter and 30-60 metres long) that rotates in operation about 3-5 times per minute. The raw material flows down through, progressively, hotter zones of the kiln towards the flame. The intense heat causes chemical reactions and physical changes that partially melt the raw meal and produce the clinker. Although there are old cement plants with less efficient technologies, as wet process kilns, nowadays most of the cement production is done in dry kiln, according to the described process.

Clinker cooling and storing

Leaving the kiln, the hot clinker is cooled using large quantities of air. In efficient plants this air used for cooling clinker and so already preheated is used as combustion air, thereby minimising overall energy loss from the system. Coolers are essential for the creation of the clinker minerals which define the performance of the cement. Clinker is then stored in hangars or silos ready for grinding or expedition. Most of the produced clinker is usually used on site to produce cement, but can be transported by truck, train or ship to other grinding plants outside of the cement plant.

Cement grinding

To get the final cement product it is necessary to add gypsum and other materials to clinker and then to grind the mixture in traditional ball mills o more efficient equipment as roller presses and vertical mills. If only around 4-5% gypsum is added to clinker the final product is called Ordinary Portland Cement (OPC), while some additional components are added to get Portland Composite Cements (PCC) with less clinker content and less CO_2 emission per ton of final product.

Cement storing and dispatch

The final product is stored in cement silos and then dispatched to either a packing station (for bagged cement) or to a silo for mass delivery and transport by water, road or rail

The rotary kiln is the heart of the cement manufacturing process where clinker is formed at very high temperature. Kiln operations conditions allow to use alternative fuel derived from wastes in a sound way for environment and to guarantee the organic components are totally burned and destroyed.

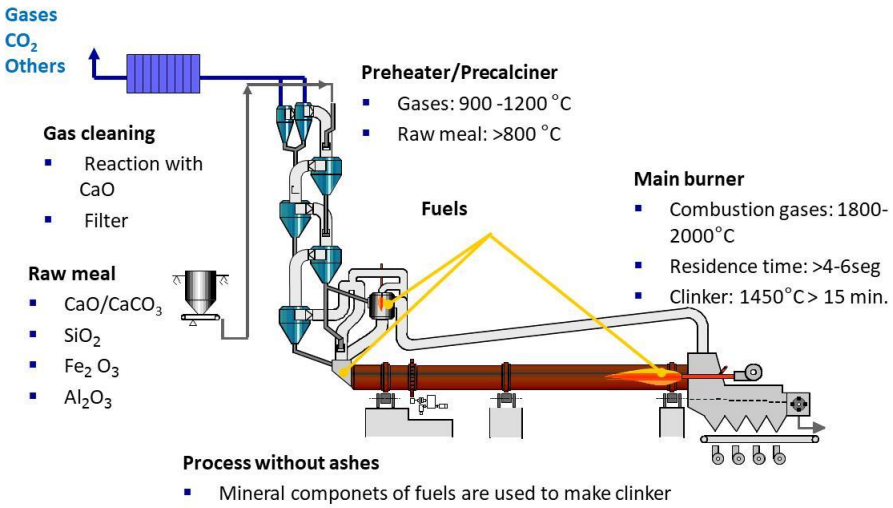


FIGURE 2. ROTARY KILN OPERATION CONDITION.
SOURCE GTZ-HOLCIM PPP. GUIDELINES ON CO-PROCESSING

2.2 WASTE CO-PROCESSING IN THE CEMENT INDUSTRY

Main impacts of the traditional cement manufacturing process are the consumption of large quantities of natural mineral materials and fossil fuels, and the emission of CO_2. The use, in cement manufacturing, of alternative fuels and raw materials, either deriving from waste or just by-products from other processes can reduce the amount of conventional fossil fuels and virgin raw materials needed, and thus reduce the overall environmental impact of the operations. See Figure 3.

Early In 2002, 10 leader cement companies, members of the WBCSD committed to a more sustainable way of producing cement adopting "the Cement Sustainability Initiative our agenda for action". The agenda declared that using waste from other industries as raw material is a huge opportunity for the cement industry to reduce its environmental impact, because it allows companies to access materials for use in the kiln and the mill without extracting them directly from the ground. Furthermore, other kinds of wastes from domestic, industrial or agricultural sources, may have little useful mineral content, but can be used as fuel alongside of traditional fossil fuels. Using these wastes is a key service that cement companies can provide to society. As well as reducing the amount of fossil fuel needed to produce cement, it prevents large volumes of material from going to landfill or being burned in incinerators.

CO-PROCESSING: it is the use of wastes in the cement process and it defined in by the WBCSD Cement Sustainability Initiative as "*an advanced and innovative process whereby energy is recovered and the non-combustible part of wastes is reused as raw material*". So co-processing is a combined operation composed of energy recovery and material recycling according to the EU legislation on wastes management, where both are considered as a recovery operation, while incineration and landfilling are considered disposal operations and hence less sustainable techniques than co-processing.

Co-processing definition is found in 2006 in the **Guidelines on co-processing Waste Materials in Cement Production,** an initiative of GTZ-Holcim Public Private Partnership, although the technique was already being used for many years. Although regulation and environmental concern have improved

drastically since that time, this document is still useful as best practice approach for companies willing to develop co-processing in cement industry, as it is the case of most of the target countries of the present report.

Developed 40 years ago in Europe, co-processing is now widely used and continuously improved all around the world. This recycling process contributes to a more circular economy, as opposed to a traditional “take-make-use-dispose” linear economy.

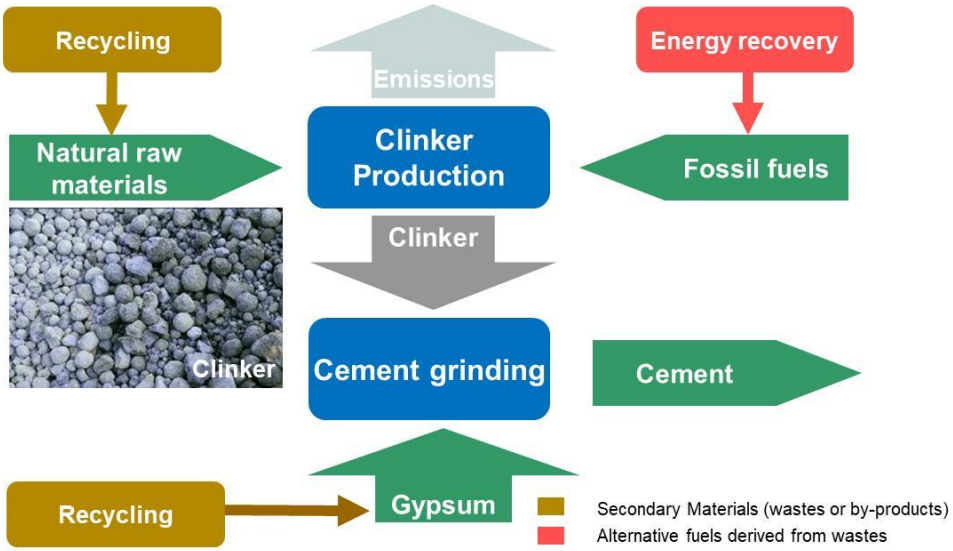


FIGURE 3. CO-PROCESING IN THE SUSTAINABLE CEMENT MANUFACTURING PROCESS

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their disposal has also adopted decisions in favour of co-processing in cement kilns. In October 2011, the 10th meeting of the Conference of the Parties approved the document on technical guidelines on the co-processing of hazardous wastes in cement kilns.

The Basel convention guidelines considered that co-processing of wastes in properly controlled cement kilns provides energy and materials recovery while cement is being produced, offering an environmentally sound recovery option for many waste materials. As countries strive for greater self-sufficiency in hazardous waste management, particularly in developing countries that may have little or no waste management infrastructure, **properly controlled co-processing can provide a practical, cost-effective and environmentally preferred option to landfill and incineration**. In general, co-processing of waste in resource-intensive processes can be an important element in a more sustainable system of managing raw materials and energy.

Earlier, in 1999, the Basel Convention had adopted another technical guideline on the management of used tires where whole or shredded end-of-life tires can be used as an alternative, supplementary fuel in cement kilns, considering that the addition of end-of-life tires is environmentally safe and does not produce additional emissions into the atmosphere of sulphur and nitrogen oxides when appropriate emission control devices are properly installed and maintained.

Nowadays the Basel Convention is preparing a guidance document on the ESM of household wastes, considering that one of the key challenges related to waste management faced by national governments and municipalities and the public, particularly in developing countries, is to achieve the prevention and

minimization of household wastes and the environmentally sound management (ESM) of these wastes. Energy recovery is considered as the sound treatment preferred to dispose of wastes.

Co-processing in cement kilns of RDF from MSW has also become a part of waste management systems in a number of developing and emerging countries and it has been promoted by the GIZ by means of a report on the matter in 2017[1], as part of the waste to energy options on municipal solid waste management.

Waste co-processing in cement kilns is a very interesting practice within the waste-to-energy approach but WtE has to be understood as a wider concept that includes other techniques addressed to get energy from wastes according to several different processes, as: combustion plants, waste incineration plants, cement and lime kilns, anaerobic digestion plants, and others.

When waste cannot be prevented or recycled, recovering its energy content is preferable to landfilling, in both environmental and economic terms. This is the reason for promoting WtE which is also in accordance with Circular Economy criteria. Moreover, co-processing is the most efficient and sustainable technique belonging to the WtE process family as it is a mix of energy recovery and material recycling which uses the waste's energy at a very high efficiency performance.

The European cement industry uses a substantial amount of waste-derived fuels, which replace fossil fuels **up to a level of more than 80 % in some plants**, but this technique has been also implemented all over the world although in some countries have been only developed at low level, what should be considered an important improvement opportunity for saving fossil fuels and reducing the greenhouse gas emissions in these countries. The main cement manufacturers have adopted this technique, mainly in Europe and developed countries, and are committed to extend it to the rest of the world.

While clear benefits are obtained from using wastes and by-product in the cement industry as alternative fuels or raw materials and the practice is according to the Circular Economy principles, **some waste streams are not suitable for this purpose**.

Moreover, wastes to be used in the cement manufacturing process must be conditioned to a proper form suitable to be managed by the cement plant and, in addition, they should be stored and fed to process with the help of specific installation suitable for this purpose.

As mentioned in the scope of the work the present study is mainly focus to energy recovery, according to the project subject: "waste-to-energy", although the mineral components of fuels are always recycled as raw material for the clinker production.

Characteristics of the clinker burning process at the rotary kiln allow environmentally beneficial waste-to-energy applications. According to Cement BREF, the essential process characteristics for the use of waste can be summarised as indicated in the next summary "**Conditions to carry out waste co-processing**".

[1] Waste-to-Energy Options in Municipal Solid Waste Management. A Guide for Decision Makers in Developing and Emerging Countries. GIZ. May, 2017

The use of waste materials depends mainly on their appropriate selection and an analysing procedure and pre-treatment: e.g. shredding, blending, grinding and homogenisation, as well as an appropriate quality assurance. In order to maintain quality standards of the clinker, these wastes have to be pre-treated and controlled, since the fuel ashes are fully captured in the clinker. The type of waste that can finally be used in a certain plant is directly linked to the clinker production process and the operation conditions, the raw materials and fuel compositions, the feeding points, the flue-gas cleaning technique used, the given waste management problems and the requirements of existing regulations.

Calorific value is a very important quality requirement necessary to improve energy efficiency and supply a positive input to the thermal process so, waste fuels should have a high calorific value. Furthermore, volumes and categories of wastes have to be considered as well as physical and chemical compositions, characteristics and pollutants.

Conditions to carry out waste co-processing

- Maximum temperatures of approx. 2 000 °C (main firing system, flame temperature)
- Gas retention times of about 8 seconds at temperatures above 1 200 °C
- Material temperatures of about 1 450 °C in the sintering zone.
- Oxidising gas atmosphere.
- Gas retention time in the secondary firing system of more than 2 seconds at temperatures of above 850 °C; in the precalciner, the retention times are correspondingly longer and temperatures are higher.
- Solids temperatures of 850 °C in the secondary firing system and/or the calciner.
- Uniform burnout conditions for load fluctuations due to the high temperatures at sufficiently long retention times.
- Destruction of organic pollutants due to the high temperatures at sufficiently long retention times.
- Absorption of gaseous components like HF, HCl, SO_2 on alkaline reactants.
- High retention capacity for particle-bound heavy metals.
- Short retention times of exhaust gases in the temperature range known to lead to ‘denovo-synthesis’ of PCDD/F.
- Complete utilisation of fuel ashes as clinker components (material recycling).
- Chemical-mineral incorporation of non-volatile heavy metals into the clinker matrix.
- No waste generation due to a complete material utilisation into the clinker matrix.

Waste can be fed into the kiln through different points:

- **Main burner**: this is the only way in which the flue-gases from fuels pass the highest temperature zone of the kiln and are discomposed in the primary burning zone at temperatures up to 2000ºC.
- **Secondary burner, preheater o precalciner**: in these feeding points, wastes are burned at lower temperatures and with residence times that depend of the kiln design and operation and which are not always high enough to decompose halogenated organic substances. So the use of halogenated alternative fuel through this point should be restricted. Volatile components in material fed at the upper end of the kiln can evaporate without being bound in the clinker so, the use of waste containing volatile metals (mercury, cadmium or thallium) or volatile organic

compounds can give raise to higher emissions when these materials are not fed into the adequate high temperatures of the kiln system.

2.3 BENEFITS OF WASTE CO-PROCESSING

Co-processing represents the final treatment step in a series of integrated waste management processes and procedures that are internationally recognized and regulated. This technique provides important benefits for the environment, the society and the economy.

FIGURE 4. BENEFITS OF WASTE CO-PROCESSING IN THE CEMENT INDUSTRY

2.3.1 ENVIRONMENTAL BENEFITS

Environmentally, co-processing provides the following benefits:

- **To contribute to the saving of natural resources**: using the waste resources (energy and mineral) co-processing reduces the need of scarce fossil fuels and virgin minerals.
- **To reduce GHG emissions**: due to the lesser average carbon content in wastes than in the traditional fossil fuel used in the cement industry, the use of alternative fuel derived from waste reduces the direct CO_2 emissions in the cement process, but furthermore while using wastes the cement sector prevents that a huge volume of them have to be incinerated or landfilled, preventing, indirectly, the CO_2 emission that these treatments would produce.
- **To destroy organic components**: flame temperature at around 2000ºC, material temperature at 1400ºC and a residence time of more than 2 seconds in an oxygen rich atmosphere ensures the destruction of all organic components. Acid gaseous compounds formed during the combustion process are neutralized by the alkaline nature of raw material and any ashes are subsequently incorporated in the clinker.
- **To recover energy from wastes and recycling its mineral components**: co-processing is a more sustainable treatment than incineration and landfilling where waste resources are disposed. Besides it is a clear example of circular economy.

- **To prevent environmental risks in landfills:** the use of wastes as alternative under strict and controlled procedures performed by the cement industry reduces the risks of fires in uncontrolled landfills as uses tires piles.

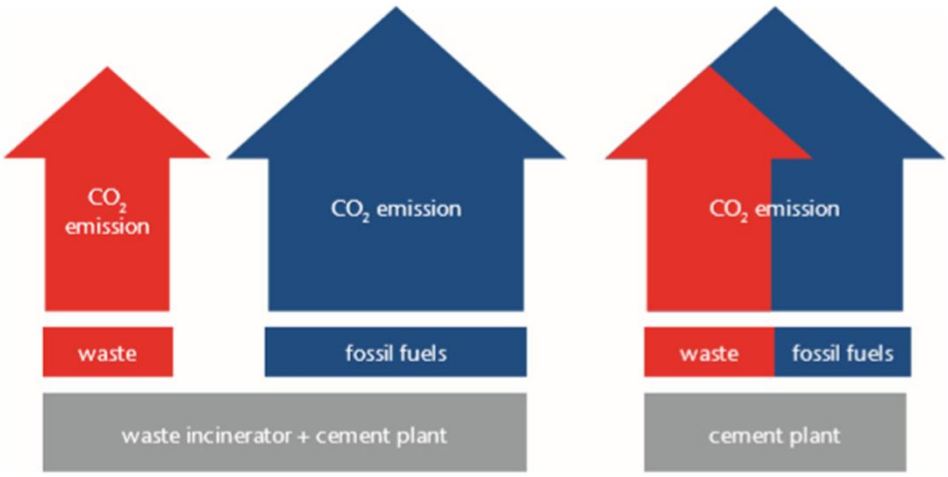


FIGURE 5. INDIRECT SAVING OF CO_2 EMISSIONS BY THE USE OF WASTE AS ALTERNATIVE FUEL IN A CEMENT PLANT SOURCE: WBCSD- CEMENT SUSTAINABILITY INITIATIVE. THE CEMENT CO_2 AND ENERGY PROTOCOL

2.3.2 SOCIAL BENEFITS

Co-processing in cement kilns also has benefits for the local community where the factory is located and for the society, as a whole:

- **To provide sound waste treatment solutions** for municipalities and other stakeholders with reduced investment, as cement capacity is available. The cement industry can solve many local waste management problems, the society has to solve in any case, and prevent the health risk for population coming from irregular dumps, or inadequate landfilling that generate important health and environmental risks for population and Environment quality.
- **To stimulate local economic activity** by creating new jobs in the waste management sector.

CASE STUDY: CONTRIBUTION OF CEMENT SECTOR TO SOIL POLLUTING REMEDIATION. ARGANDA DEL REY LAGOON (MADRID / SPAIN)

Industrial activities could have produced soil contamination, either by accident or due to bad practices in waste management. This was the case of an old waste oil treatment installation in Arganda del Rey (Spain) resulting in water and soil contamination. Regional authorities assumed the remediation responsibility as the polluter company became bankrupt time ago.

Leaks of waste oils products generated a high environmental impact polluting a nearby lagoon. The regional government appointed two public companies to solve the problem. The first rehabilitation project was designed by EMGRISA (a public company on waste management) and then, another public company (TRAGSA) was in charge of providing a global solution.

FIGURE 6. ARGANDA DEL REY LAGOON. SOURCE: DIARIO DE RIVAS

The Spanish cement sector contributed to solve this environmental problem thanks to the co-processing the oily liquid fraction in authorized cement plants, as a part of the country waste management infrastructure, demonstrating how waste co-processing in cement kilns can provide valuable environmental services concerning local waste management.

Waste oil used to be one of the first alternative fuels used by the cement industry, but due to innovation changes it is no longer an important source of alternative fuel in Europe, as they are usually recycled, so the cement sector was prepared to provide this punctual service. Nevertheless this is not the case in emerging countries where waste oils represent a serious risk for water and soils pollution and in those cases the cement industry could provide a very sound co-processing solution until another recycling one will be locally developed.

2.3.3 ECONOMIC BENEFITS

The implementation of waste co-processing in a cement plant produces economic benefits for the community and for the cement factory itself. These ones are:

- **To provide a cost-effective waste management solution**: the community can benefit from an environmental waste management service at a reasonable cost.
- **To reduce cement production cost and to increase competitiveness**: the cement factory can reduce operation cost and become more competitive in the global market where cement is nowadays a commodity.

Operational data (input)	
Typical coal LHV (MJ/kg)	25,92
Typical RDF LHV (MJ/kg)	16,72
RDF consumption (t/h)	6,00
Daily operation time (h/d)	24
Annual operation time (d/y)	340

Payback: 2,47 months

Operational costs (input)	
Monthly electrical cost (€)	4.990,00
RDF supply cost (€)	5.000,00
RDF cuality control cost (€)	5.000,00
Estimated coal cost (€/t)	90,00
Estimated RDF cost (€/t)	10,00
Estimated electricity cost (€/kwh)	0,11

Installation CAPEX (input)	
Receiving and dosing unit (€)	400.000
Civil works(€)	15.000
Installation cost (€)	50.000
Electrical and regulation system update (€)	10.000

Instalación CAPEX (ouput)	
Coal saving (t/h)	3,87
Fuel cost saving (€/h)	288,30
Daily fuel cost saving (€/d)	6.919,20
Monthly fuel cost saving (€/m)	207.576,0

Instalación CAPEX (input)	
Annual fuel cost saving (€/y)	2.352.528
Total monthly economic saving (€/m)	192.586
Total savings (1 year)	1.836.032
Total savings (2 years)	4.147.064

FIGURE 7. ECONOMIC BENEFITS OF CO-PROCESSING. SOURCE: FLSMIDTH

CASE STUDY: INVESTMENT IN ZUBIETA PLANT (NAVARRA / SPAIN) (Source. Rafael Salgueiro)

The economic public investment has been evaluated in Zubieta plant. It has been considered that it would be necessary to build a new facility every 200.000 new co-processed tons. This means a potential saving of 217 to 651 Million€ of public investment, as well as 11,4 to 34,3 Million€ non payable waste treatment tax (reference average cost: 57€/t in 9 Spanish plants). This impact can be translated to individual figures: a co-processing plant will give the solution for 597.000 inhabitants in a region producing annually 335 kg/person of potential co-processed waste. This will be equivalent to 363Million€ savings and a tax of 19€/person for waste treatment.

2.4 TYPE OF WASTES FOR THE WASTE TO ENERGY PROCESS

Wastes are commonly understood as an interesting source of energy suitable to be used according to Circular Economy criteria. As far as the EU is concerned, the energy recovery from waste and its place in the circular economy has been recently emphasized by the Commission after evaluating its potential by mean of a JRC report where wastes families are classified according to Eurostat Waste Statistics. The potential for the waste to energy processes has been deeply studied in a report by the JRC. and then promoted by the Commission.

The JRC report analysed the energy embedded in the different streams of waste and the final use of them, as it is shown in Table 1.

	Incineration (D10+R1) (PJ[2])		Landfill / disposal (D1-D7-D12) (PJ[2])		TOTAL	
Wood wastes	375	21%	7	0%	382	11,89%
Plastic wastes	61	3%	51	4%	112	3,48%
Paper and cardboard wastes	6	0%	3	0%	9	0,28%
Textile wastes	2	0%	3	0%	5	0,16%
Waste tires	35	2%	2	0%	37	1,15%
Spent solvents	29	2%	0	0%	29	0,90%
Waste oils	32	2%	0	0%	32	1,00%
Chemical wastes	93	5%	31	2%	124	3,86%
Household and similar wastes (HSW)	470	26%	616	44%	1086	33,79%
Mixed and undifferentiated materials	149	8%	120	9%	269	8,37%
Sorting residues	334	18%	489	35%	823	25,61%
Animal and vegetal wastes[1]	70	4%	80	6%	150	4,67%
Dried municipal sewage sludge [1]	22	1%	7	0%	29	0,90%
Waste-derived biogas[2]	108	6%	0	0%	108	3,36%
Waste-derived biodiesel[2]	19	1%	0	0%	19	0,59%
Total	**1805**	**100%**	**1409**	**100%**	**3214**	**100%**

TABLE 1. AMOUNT OF WASTE EMBEDDED ENERGY SENT TO INCINERATION OR TO LANDFILL/DISPOSAL IN 2012 IN THE EU. SOURCE: JRC

In the JRC report, following EUROSTAT criteria, the different waste streams suitable for WtE process are defined as follows:

- **Wood wastes** are wooden packaging, sawdust, shavings, cuttings, waste bark, cork and wood from the production of pulp and paper; wood from the construction and demolition of buildings; and separately collected wood waste. They mainly originate from wood processing, the pulp and paper industry and the demolition of buildings but can occur in all sectors in lower quantities due to wooden packaging. **Wood wastes are hazardous when containing hazardous substances like mercury or tar-based wood preservatives**. Energy recovery is the main treatment for these wastes in the EU.
- **Plastic wastes** are plastic packaging; plastic waste from plastic production and machining of plastics; plastic waste from sorting and preparation processes; and separately collected plastic waste. They originate from all sectors as packaging waste, from sectors producing plastic products and from separate sorting by businesses and households. **All plastic wastes are non-hazardous**. A distinction should be made between plastic wastes and mixed packaging that belongs to the category 'mixed and undifferentiated materials'. **Material recovery is the main treatment but energy recovery has an important contribution**.
- **Paper and cardboard wastes** are paper and cardboard from separate sorting by businesses and households. This category includes fibre, **filler and coating rejects from pulp**, paper and cardboard production. These wastes are largely generated by three activities: **separate collection**, **mechanical treatment of waste and pulp**, and paper and cardboard production and

processing. **This type of waste is considered as non-hazardous**. Energy recovery represents 40% of their management options.

- **Textile wastes** are textile and leather waste; textile packaging; worn clothes and used textiles; waste from fibre preparation and processing; waste tanned leather; and separately collected textile and leather waste. They come from only a small number of activities: the leather and fur industry, the textile industry, the mechanical treatment of waste and source separate collection. **They are considered as non-hazardous**. Energy recovery is the main treatment for them.
- **Tires and rubber wastes** are end-of-life tyres which come from the maintenance of vehicles, and end-of-life vehicles. **All rubber wastes are non-hazardous**. They can be generated in all sectors. Energy recovery is the main treatment for used tires reaching more than 50% of which co-processing in cement kilns account for more than 92%.
- **Spent solvents** are hydrocarbons, fluorocarbons, chlorinated carbons; organic halogenated, non-halogenated solvents, including organic washing liquids; and organic fluorinated refrigerants. They are used in chemical industries as reaction agent and in extraction processes, cleaning processes in mechanical engineering and surface treatment and appear almost exclusively in the manufacture of chemicals, chemical products, basic pharmaceutical products and preparations, and rubber and plastic products (item 9 of Section 8 of Annex I of the Waste Statistics Regulation). To a lesser extent, this type of waste can also be generated during the fabrication of metal products and during recycling. Separately collected fractions of spent solvents can be generated by almost all economic activities, including private households. **Spent solvents are considered as hazardous waste** and energy recovery is the main treatment for them accounting to 35%.
- **Waste oils are hazardous wastes** mainly coming from automation maintenance works and they were formerly used as an important alternative fuel for the cement industry, nevertheless nowadays their main treatment is recycling.
- **Chemical wastes** are solid or liquid spent **chemical catalysts; off specification products** and wastes like **agro-chemicals, medicines, paint, dyestuff, pigments, varnish, inks and adhesives**, including related sludge; chemical preparation waste like preservatives, brake and antifreeze fluids, waste chemicals; tars and carbonaceous waste **like acid tars, bitumen, carbon anodes**, tar and carbon waste; fuels, emulsions, sludge containing oil, like bilge oil, waste fuels oil, diesel, petrol, waste from oil water separator; aqueous rinsing and washing liquids, aqueous mother liquors; spent filtration and adsorbent material like activated carbon, filter cakes, ion exchangers. They mainly originate from the chemical industry and from various industrial branches producing and using chemical products. They are considered hazardous waste when containing toxic chemical compounds, oil, heavy metals or other dangerous substances. Energy recovery is a usual treatment but not the main one. Concerning the use as alternative fuel in the cement industry it is necessary to do an important conditioning process in a pre-processing installation in order to prepare quality fuels.
- **Household and similar wastes** are mixed municipal waste, bulky waste, street-cleaning waste like packaging, kitchen waste, and household equipment except separately collected fractions. They originate mainly from households but can also be generated by all sectors in canteens and

offices as consumption residues. Household and similar wastes **are non-hazardous**. Landfilling used to be the main treatment in the EU but implementation of waste regulation and circular economy criteria are reducing drastically landfilling. In any case it depends very much on each country.

- **Mixed and undifferentiated materials** are unspecified and mixed waste without any general source. This category covers not only mixed packaging but also mainly residual categories from different branches of industry (food production, textile industry, combustion plants, surface treatment of metals and plastics, etc.). These residual categories are often used for nation-specific waste codes. Mixed and undifferentiated materials **are hazardous when containing heavy metals or organic pollutants**. Wastes sent for energy recovery represented about 20% of the waste generation in the EU-28.
- **Sorting residues** are wastes from mechanical sorting processes for waste; combustible waste (refuse derived fuel); and non-composted fractions of biodegradable waste. They mainly originate from waste treatment and source separate collection. Sorting residues from demolition activities are excluded. They are **considered hazardous waste** when containing heavy metals or organic pollutants. According to Eurostat Waste Statistics, wastes sent for energy recovery represented about 26% of the sorting residues generation in the EU-28.
- **Animal and vegetal wastes.** In the UE context there are three categories of wastes included in this classification: animal and mixed food waste; vegetal wastes and animal and animal faeces, urine and manure. Energy recovery was not important for these wastes although animal meat represented an important alternative fuel during the mad cow disease when the cement industry was required to burn it.
- **Dried municipal sewage sludge**. The accumulated settled solids separated from various types of water either moist or mixed with a liquid component as a result of natural or artificial processes. The cement industry can only deal with dried sewage sludge in the range of **15-18%** humidity, so it is necessary to have drying capacity in the country to prepare the wet sludge into alternative fuels for co-processing.
- **Waste-derived biogas, waste derived bioethanol and waste derived biodiesel** a less important concerning the purpose of the present report as they are not used as AF fuel for co-processing**.**

This means that acting only on household wastes it is possible to recover a significant part of the energy contained on the wastes generated in a country.

Although waste generation depends on the country the European information can be used as a general overview useful as guideline for other non EU countries. In emerging countries, the weight of industrial wastes would be lower, but the municipal wastes would continue being the main option for the waste to energy process what is quite challenging **municipal wastes management represents a serious environmental and health problem in those countries.**

Main **conclusions** from the report could be summarized as follows:

- Household wastes represent more than 33% of the energy embedded in the total waste generation.
- 2 waste streams only - household and similar wastes (HSW) and sorting residues - account for more than three quarters of the energy contained in landfilled waste.
- 3 waste streams only - household and similar wastes (HSW), sorting residues and wood waste – account for nearly two thirds of the energy contained in waste sent for incineration.
- 6 types of waste together contain 83% of the total energy embedded in wastes sent to incineration and 93% of the total energy embedded in wastes sent to landfill.

2.5 INSTALLATIONS FOR WASTE CO-PROCESSING

2.5.1 WASTE CONDITIONING/PRE-PROCESSING INSTALLATIONS

Waste co-processing in cement sector requires a previous step for conditioning wastes into alternatives fuels (Pre-processing) suitable to be used at the cement kiln, as wastes as they are produced are difficult to be used directly. The main objective of these pre-processing installations is to get homogeneous fuels with the quality required by the cement kiln to be properly operated. Calorific value, particle size, halogen and heavy metals' content must be homogeneous and controlled to guarantee a steady and regular kiln operation and emissions according to environmental regulations and plant permits.

Herein there are some examples of waste in the way they have been produced and, once they have been processed and they are ready to be used as alternative fuels.

Waste: used tires, non recyclable plastics, paints, etc.

AF pre-processed: Shredded tires, RDF plastic, impregnated saw dust, etc.

FIGURE 8. WASTE CONDITIONING. SOURCE: FLSMIDTH AND OWN PRODUCTION

Common conditioning operations at the pre-processing platforms are: liquid blending, solid shredding, drying and mixing, quality control operations.

- **Production of RDF from MSW through biological-mechanical process**

MSW can be used to produce important volumes of RDF preferably when there is a separate collection for wastes but also when this system has not been implemented yet and the waste flow is “all in one”. When separate collection has been set up the source for RDF production is only the “rest fraction”, as the so called “yellow bag” is used for recycling purposes.

MSW flow entering the plant is shredded and then mechanically separated in three flows: recycled materials, mainly metal, plastics and paper; little size components, mainly wet organic material and finally a dry fraction containing a mix of diverse materials. Wet fraction is fundamentally addressed to compost production while the dry flow could be used to produce RDF.

As the main purpose of these plants is the compost production, the dry fraction contains some useless material for the RDF production, so it is necessary to do a second shedding operation and then a pneumatic separation in two flows; a low density material separated by sucking, containing small pieces of plastics, paper, wood, textiles and others with a nice calorific value and a heavy fraction containing inert material and another elements with low calorific value.

Some of the former MSW plants in operation has not been designed taking in account the RDF production because they were thought to produce compost, recycle useful material and landfill the rest, so the production of RDF in such a kind of plants need an upgrade of them. Nevertheless, nowadays the use of compost for agriculture is increasingly regulated and landfilling is more and more restricted, in order to fulfil Circular Economy criteria and prevent environmental impact of landfills. For this reason, all new MSW treatment plants should be designed and operated to produce quality RDF since the very beginning. This is an opportunity for developing countries where waste infrastructure needs to be created.

Although there are dedicated treatment plants to produce high quality RDF only from commercial wastes this kind of waste can be also treated in the MSW plants prepared to produce RDF when there is not a developed recycling infrastructure in a country.

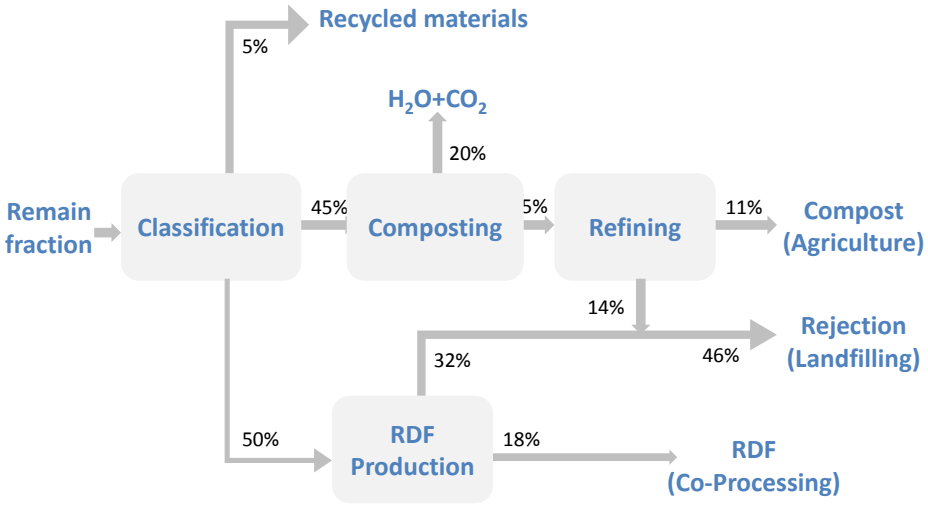


FIGURE 9. BIOLOGICAL – MECHANICAL TREATMENT PLANT. SOURCE: ISR AND OWN PRODUCTION

CASE STUDY: PRODUCTION OF RDF FROM MSW BY BIO-DRYING PROCESS IN CERVERA DEL MAESTRAZGO (CASTELLÓN / SPAIN)

MSW plants could be designed principally to produce high quality RDF stead of prioritize the compost production. In this case an option is a bio-drying process.

Main steps of this process are: MSW reception, shredding, bio-drying, gas treatment, automatic and manual separation of different materials, densimetric separation of the high calorific fraction and final shredding for producing RDF. In parallel another operations take place to obtain several flows including recycling materials and inert fraction to landfill.

After reception, MSW are shredded to 20-30 cm size and stored in piles within a fermentation building. Aerobic fermentation of organic materials, helped by forced air circulation, increases the waste temperature up to reach 50-60 ºC in the ventilation air flow for 14 days about. Wastes lose more than 30% of their original weight and reduce moisture up to 13 % about.

Due to the fermentation process the organics material is almost eliminated while gases from the fermentation are sucked towards the bio-filter where contaminant substances like ammonia or H_2S are transformed by microorganisms, in proper conditions of pH, moisture and residence time. Bio filter consists of wood chips slightly compacted covered by pine bark.

Dried waste is mechanically separated by sizes in a trommel screen in two flows: low size flow (inferior to 80 mm about) is considered as inert material while bigger size flow are additionally treated to separate different materials for recycling and another flow suitable to produce RDF. This flow it treated in a densimetric separator. Only the lighter fraction from the separator is shredded again to produce the final RDF that can be used as quality AF in cement plants.

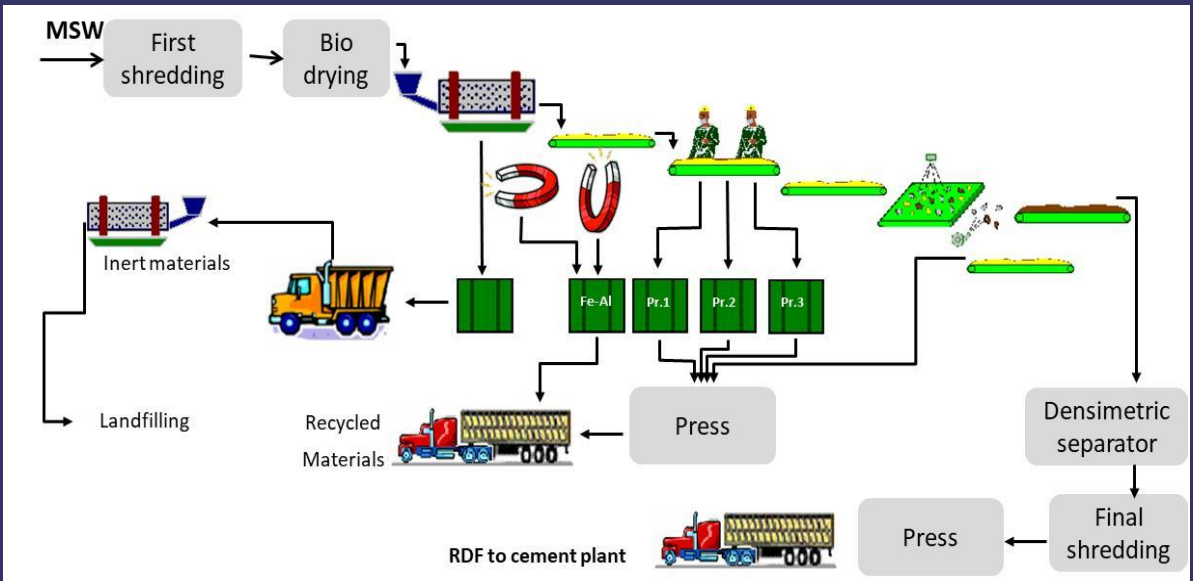


FIGURE 10. BIODRYING PROCESS WORK FLOW.
SOURCE: UTE ZONA 1 AND OWN PRODUCTION

- **Production of AF from hazardous industrial wastes**

Industry represents the second most important source of waste for co-processing after MSW, but due to the wide range in chemical and physical properties, size of containers and special applicable regulations, a proper qualified pre-treatment is required to prepare AF suitable to be used in the cement kiln. Excepting the case of very big facilities, industrial wastes are delivered to a pre-treatment installation where they are processed into quality AF either as liquid material or as powdered fuel, before being accepted at the cement plant.

A typical pre-treatment installation suitable to pre-treat different kinds of hazardous wastes should be composed of the following areas:

- Waste reception process
- Liquid AF production line
- Solid AF production line
- Auxiliary installations.

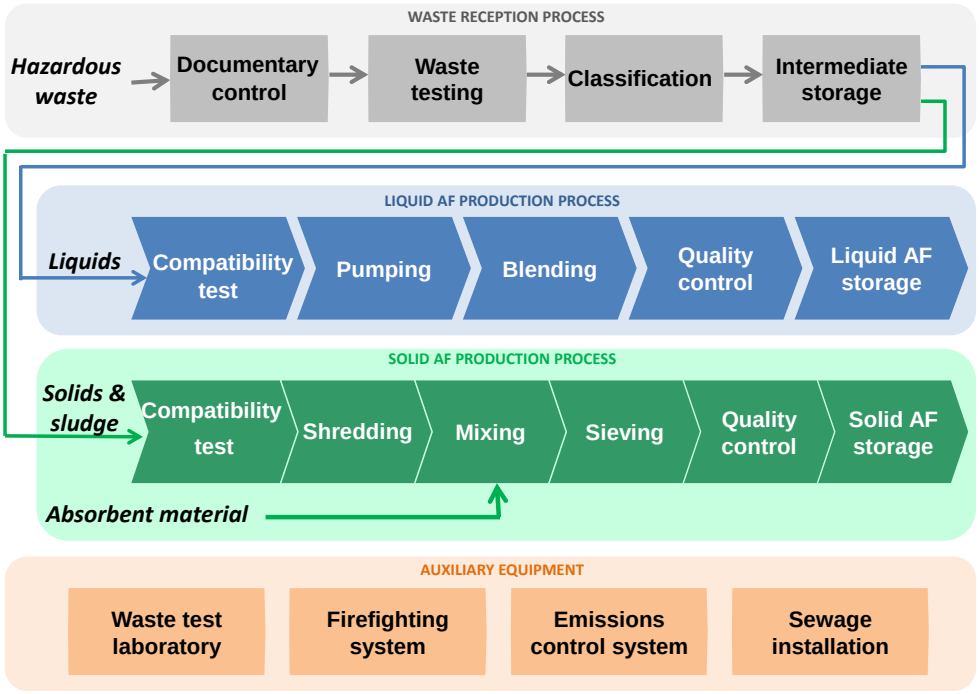


FIGURE 11. HAZARDOUS WASTE PRE-TREATMENT INSTALLATION

There are simple installations only for blending liquid wastes but they can provide only partial solutions. Wastes coming either from producers or collecting companies must be checked documentarily and then tested before being accepted. Then they are properly identified, classified and stored, taking in account the safety rules.

Compatibility tests are made to all wastes entering the pre-treatment installation before being stored. Then, liquid wastes, either coming from producers or picked up from intermediate storage, are blended by pumping or mixing and stored for delivery, previous quality control to the cement plant. Concerning solid waste, they are already classified and stored according to their compatibility and then, they are shredded and mixed with absorbent material such as saw dust or similar ones, in order to get a suitable consistency to be used at the cement kiln like petcoke or coal.

A quality pre-treatment installation for hazardous waste should be equipped additionally with a testing laboratory, a fire fighting system, an emissions control system and a sewage installation.

2.5.2 PLANT INSTALLATIONS FOR USING ALTERNATIVE FUELS

Alternative fuels used for co-processing in cement kilns require special installations for acceptance quality control and for storage and feeding to the process. Furthermore, the plant factory needs to enhance abatement installations and emission control installations to honour the permit requirements.

Waste laboratory installations are common for all kinds of wastes, while storage and feeding installations are specific ones depending of the physical and chemical characteristics of waste and on the feeding point to the process.

2.5.2.1 WASTE LABORATORY

In order to guarantee that alternative fuels comply with the authorized specifications in the plant co-processing permit, acceptance controls are normally implemented on the waste arrival to the cement plant. Authorities can release this requirement in case of standard and regular wastes (used tires) or when the alternative fuels come from a conditioning waste platform that certificates the alternative fuel quality. **Cement plants using hazardous waste as alternative fuels have normally laboratories equipped with the proper devices able to measure several waste parameters: calorific value, halogens (Cl, F, Br), heavy metals** (Hg, Cd, Tl, As, Sb, Ni, Cu, Co, Sn, Cu, Cr, V, Pb, Mn), PCB,s, % H_2O, % sulphur, density, viscosity, ashes, pH, chemical compatibility.

2.5.2.2 ALTERNATIVE FUELS STORAGE AND FEEDING

Storage and feeding installations are quite specific depending on the waste physical characteristics. For liquid wastes, temperature, flash point, viscosity are key parameters to design the proper installation. As far as solids are concerned, particle size, density or dimensions are essential.

In Table 2 there is a resume of most common alternative fuel installations in cement plants

	Feeding point to kiln		
Waste characteristics	**Main burner**	**Preheater or Precalciner**	**Middle of the kiln**
Liquids	X		
Small size solids	X	X	
Fluff (RDF)	X	X	
Slurries		X	
Coarse solids		X	
Bulky solids		X	X

TABLE 2. AF INSTALLATIONS IN CEMENT PLANTS

Installations for liquid alternative fuels

Installations for liquid alternative fuels are quite similar to chemical industry installations and consist of: **storage tanks, pumping system, filters, piping, control devices and a fire-fighting system.**

The **sort of waste** managed in these installations is: organic solvents, waste oils, waste water with little particles content.

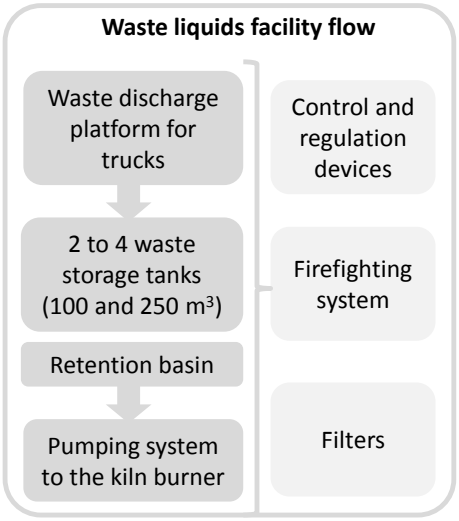


FIGURE 12: LIQUID AF INSTALLATION. SOURCE: VOTORANTIM AND INERCO

Installation for small size solid alternative fuels

Powdered and fine solids AF are stored in silos and fed to kiln mainly by means of pneumatic or mechanical systems. This could be the case for animal meals, where, due to heath reasons, the product must be stored in dust-tight silos. This kind of silo installation could be also used for dry sewage sludge, in order to prevent other issues.

FIGURE 13. INSTALLATION FOR POWDERED SOLIDS.
SOURCE: HEIDELBERG

FIGURE 14. INSTALLATION FOR ANIMAL MEAL.
SOURCE: HEIDELBERG

FIGURE 15. DRIED SLUDGE INSTALLATION
SOURCE: FLSMIDTH

Installation for RDF alternative fuels

Fluff type alternative fuels like plastics or RDF are stored in hangars and fed to process mechanical or pneumatically, depending on the size and density.

These alternative fuels are very variable, so a step-wise approach is recommended, starting by a simple installation able to check alternative AF utilization at the plant and ensure the supply channel feasibility. It is possible even to get temporary installation in a renting regime to perform a co-processing test that could be required by authorities in some countries as a condition to grant the final co-processing permit.

The simplest installation is a small receiving volumetric dosing unit coupled to a screw conveyor, a rotary valve and a blower for pneumatic transportation to the kiln. This is a very cheap installation that allows to start co-processing before accomplishing important capex in permanent expensive installations. A second step could be a receiving and gravimetric dosing unit for continuous AF supply at a higher rate, which is coupled to a drag chain conveyor, a weighting system and a blower for pneumatic transportation.

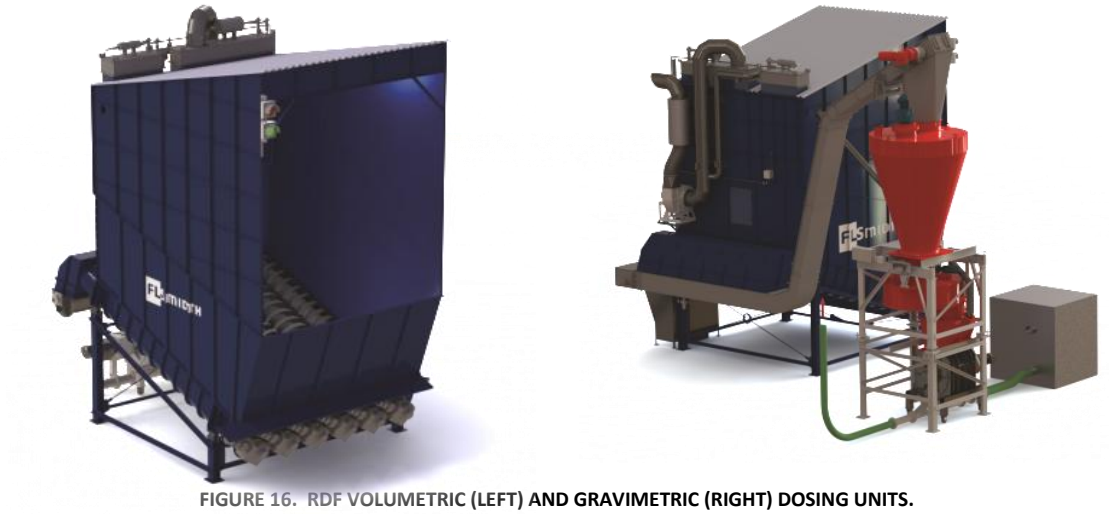


FIGURE 16. RDF VOLUMETRIC (LEFT) AND GRAVIMETRIC (RIGHT) DOSING UNITS.
SOURCE FLSMIDTH

When co-processing is going to be developed at high level, permanent and high rate installations are required. This type of installations consist of big silos with different forms and materials, as concrete or steel, and different systems for material extracting, such as screw bottom or push floor; weighting devices for accurate AF dosing and a transportation system to burners, either at the kiln end or the precalciner.

FIGURE 17. ENERFUEL-RDF (LEFT) AND ENERFUEL TRANSPORTATION (RIGHT)
SOURCE: CEMEX ESPAÑA, S.A

FIGURE 18. RDF STORAGE AND EXTRACTION (LEFT) AND GENERAL VIEW RDF INSTALATION (RIGHT)
SOURCE: CEMEX ESPAÑA, S.A.

Installations for coarse alternative fuels

Coarse alternative fuels are stored in conditioned pits and then mechanically extracted and fed to the kiln entrance by means of a conveyor.

FIGURE 19. RECEPTION FOR SHREDDED TIRES
SOURCE: VOTORANTIM

FIGURE 20. SHREDDED TIRES PICKING UP.
SOURCE: CEMEX ESPAÑA, SA

FIGURE 22. SHREDDED TIRES DOSING AND FEEDING.
SORUCE: CEMEX ESPAÑA S.A

FIGURE 21. SHREDDED TIRES KILN FEEDING CONVEYOR
SOURCE: HEIDELBERG

Installation for lump alternative fuels

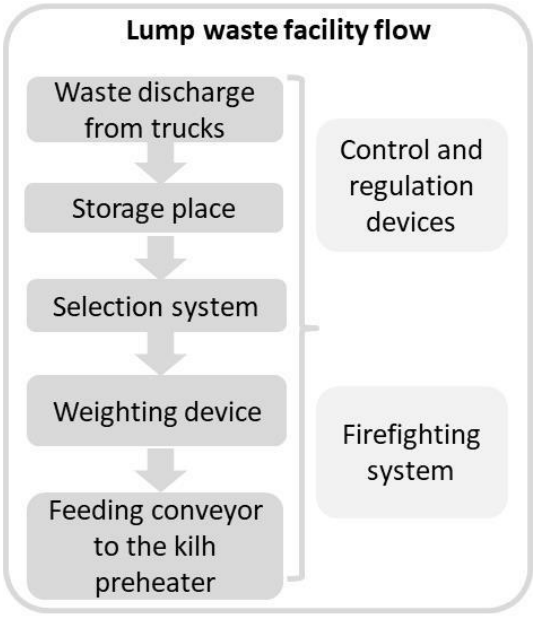


FIGURE 23. LUMP WASTE CO-PROCESSING INSTALLATION FLOW CHART

For bulky solid like whole tires or bales special installations are required. A typical installation for whole tires consists of the following parts: storage area, extraction mechanism-normally by mobile floor, weighting system, feeding conveyor and double lock inlet. Firefighting system is also included in the installation scope.

Whole tires are received from the waste management company by truck and are stored in an especial area conditioned for this purpose. Tires are mechanically fed to a mobile floor device where they are selected by the extraction device, fed to a conveyor feeding the weighting system and they are finally sent to the kiln entrance by of a long rubber conveyor suitable to reach the kiln height with a slight slope. A double lock at the kiln chamber feeds tires to the kiln according to the frequency managed by the weighting control system, in order to guarantee a regular fuel supply to the kiln. To prevent fire risks, quite difficult to stop, fire monitoring and control system should be incorporated.

Other additional installations

Emission limits on cement plants operating with waste co-processing are stricter than those allowed when only conventional fuels are used. Besides, emissions parameters range to be controlled is wider. These requirements obligate cement plants to revise its environmental performance and to improve installations to adapt the plant operation to the environmental permit conditions. Better filter efficiency and additional emission control devices are compulsory.

Continuous measurement devices are required to be installed at stack to monitor emissions of pollutants according to the environmental plant permits for co-processing. Equipment should be able to measure the following parameters: dust, HCl, HF, SO_2, NO_x, TOC and, in some cases, ammonia.

Furthermore, spot measurement campaigns have to be done by external certificated measurement companies, to check emission of dioxins and furans and heavy metal as well.

2.6 BUSINESS MODELS FOR CO-PROCESSING DEVELOPMENT IN THE CEMENT INDUSTRY

Waste co-processing is an environmental service provided by the cement sector as a fundamental partner within the waste management infrastructure of the country. Cement plants are able to provide final treatment to a wide range of wastes.

As shown in point 2.3 of this report, co-processing produces clear benefits for Environment, for Society and for Economy but it is fundamental that it also generates a positive contribution to the cement business in order to reduce operation cost and enhance competitive situation of the cement plant.

Figure 24 shows the global business model of waste management, where co-processing is part of it.

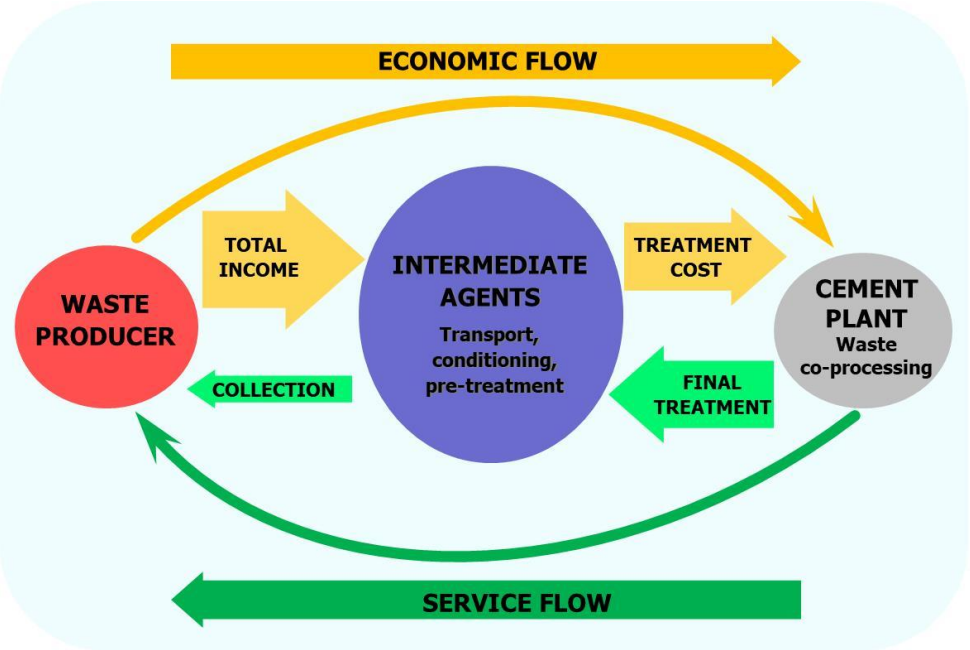


FIGURE 24. BUSINESS MODEL FOR WASTE CO-PROCESSING IN THE CEMENT INDUSTRY

The main reason for this business model is based on the principle **"the polluter pays**". So waste producer is responsible for his wastes and has the duty of paying for their correct management. When the producer delivers waste to a waste management agent, he has to pay enough money in order to ensure a proper management including transport, conditioning and final treatment. Unfortunately, this scheme is not working at countries with scarce environmental regulation or poor commitment, where wastes are not properly managed and disposal in landfills or in cases where dumping is the common practice.

Due to the characteristics of alternative fuels -essentially wastes- the business model of waste co-processing should not be considered as a purchase activity searching another kind of fuels for the cement sector. It is necessary to have a comprehensive knowledge of wastes, its chemical and physical risks and the health and safety procedures that must be taken into account to deal with them.

Waste co-processing should be understood as part of a long process of waste management including internal cement plant operations and external ones; all of them must be taken into account within the service business analysis. Furthermore, the co-processing activity requires some additional tasks in cement plant operations in relation to those performed in traditional cement plants.

EXTERNAL OPERATIONS

They include all steps from the waste generation to waste reception as AF fuel at the cement plant.

- **Waste generation**

  To know the generation of wastes and the waste management organization in a country it is essential to develop a co-processing strategy. In general, industrial wastes are under the producer's responsibility and household wastes are under the municipality responsibility.

  According to the polluter pays principle this point is the basis (principle) of the value chain.

- **Waste collection**

  This step depends very much on the country waste management organization. The more developed is the system the easier is to find opportunities for co-processing. Collection cost must be considered within the waste value chain.

- **Waste pre-processing**

  Only a few waste types can be used directly by the cement plant, so that, pre-processing capacity able to condition wastes into alternative fuels is the most critical point to create real co-processing opportunities. Pre-processing cost represents a significant part of the value chain.

  In case there is no local pre-processing capacity the cement company can decide to create its own plant and to develop a more integrated waste management service, including collection, for those interesting waste families suitable for co-processing. Pre-processing capacity can also be set up by means of joint ventures of cement companies with local collectors.

- **AF transfer to cement plant.**

  Prepared AF in the pre-processing plant have to be supplied to the cement plant. This is a simple transport operation but it should be done only by authorized waste management agents, in order to guarantee the safe keeping. Special vehicles are normally required for this purpose depending on the waste characteristics.

INTERNAL OPERATIONS

- **AF reception and quality control**

  In order to guarantee the quality of receiving AF the plant should implement controls to be sure the cement plant only receives those fuels authorized by the permit. Waste control laboratories are required mainly when AF are hazardous materials as described in 2.5.2.

- **AF storage and dosing**

  The use of AF requires normally of specific installation to store and dose them to kiln. This represents a significant investment cost which feasibility should be financially evaluated, as the waste management market is quite dynamic and it is permanent changing. Expensive installations are not justified except the AF availability is granted.

- **Kiln operation with AF**

  The use of AF always means a challenge for plant operation as it represents some changes in respect to the previous conditions. This is, essentially, a staff training matter, but OH&S aspects should be taken into account, mainly when hazardous materials are used.

ADDITIONAL QUALITY AND CONTROL PLANT OPERATIONS

- **Kiln emission controls**

  The permit for co-processing sets up additional emission controls respect the plant operation with traditional fuels. This means both the need of continuous measurement emissions equipment and the performance of spot test by external specialized companies. All these represent an additional cost that must be considered in the business value change.

- **Clinker quality controls**

  Although the clinker quality tests are a routine task in any cement plant, the influence of AF utilization should be specifically controlled, in order to guarantee always the clinker high quality required by the construction material regulations. In conclusion, co-processing is an interesting solution for solving local waste management problems and to contribute to a more sustainable cement production, but **it requires a proper business approach in order to guarantee all the aspects have been considered and its implementation is feasible in each single cement plant.**

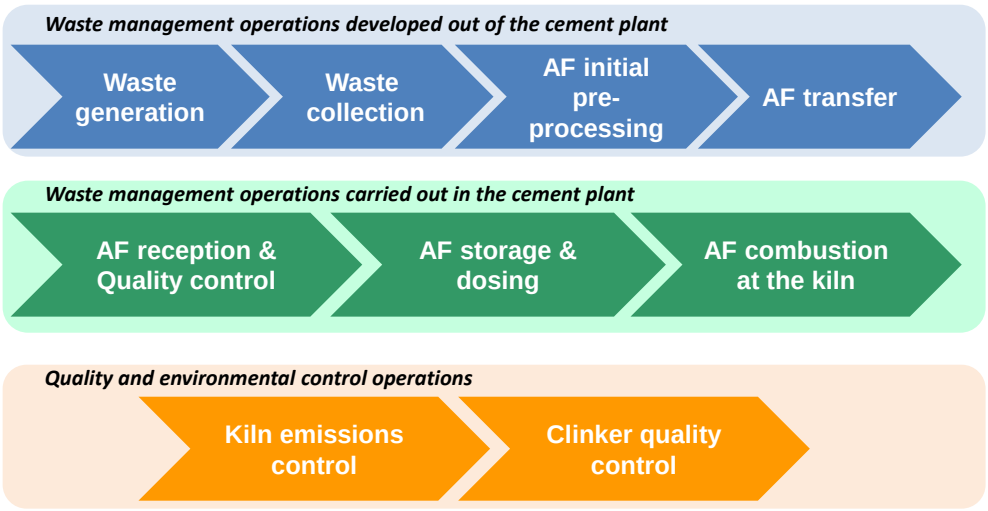


FIGURE 25. ALTERNATIVE FUELS VALUE CHAIN

3 BARRIERS AND SOLUTIONS TO THE WASTE CO-PROCESSING DEVELOPMENT IN THE CEMENT SECTOR

3.1 REGULATION AND ADMINISTRATIVE BARRIERS

1) **No clear regulations for waste co-processing**: co-processing activity in the cement industry needs to be clearly regulated in order to avoid any sort of social or environmental problems, due to either people misunderstandings or bad practices due to the lack of a regulatory framework and standards.
   Solution:
   - To Improve waste management law enforcement and to develop a regulatory framework for this activity (governments, municipalities).
   - To establish appropriate emission limit values for cement plants (for instance, Tunisia has adopted specific limits to carry out RDF co-processing last year).
2) **Poor administration support to waste co-processing:** although waste co-processing is allowed there is not enough support from local and national governments due to social issues.
   Solution: proactive Administration support to cement industry on this activity is required.
3) **Poor availability or low enforcement of waste management regulations:** low commitment to Circular Economy principles and a high tolerance towards irregular landfilling are two of the root causes for the strong difficulty to carry out waste co-processing in the cement industry.
   Solution: a sustainable environmental policy and public surveillance on waste management will push the waste-to-energy and therefore co-processing activities.
4) **Long time to get the plant permit to carry out the waste co-processing activity**: it is mandatory for the plant to have a permit for co-processing. This is a highly time consuming step as it involves negotiations not only with the authorities and public bodies, but also with different stakeholders (NGO's, neighbours, etc.).To get the permit, it is necessary to demonstrate that:
   - The cement plant complies with all the specific legal and administrative requirements (environmental, safety, etc.).
   - Every waste included in the permit application is suitable for co-processing.
   - All the infrastructure and facilities required for undertaking pre-processing or co-processing will be available.

   Solution: to alleviate the bureaucratic barriers decreasing the waiting time for permit issuance.
5) **Very short and narrow co-processing permits:** after a long period to get the permit, the plant losses opportunities to co-process certain waste due to the high restrictions to use them.
   Solution: To be more flexible and to grant wider permits to increase co-processing rate.

3.2 SOCIAL ISSUES

1) **Lack of social acceptance**: support to waste co-processing by stakeholders such as groups of waste co-processing, NGOs or local residents in the cement plant is necessary as, public pressure can significantly limit the possibility of waste combustion. They often perceive this activity as waste incineration and automatically reject it.

   Solution:

   - To continue the efforts to gain the public acceptance for developing co-processing, stimulating an open debate and transparency between the opposition groups, public and the cement industry.
   - To enhance ESD throughout the schooling system and beyond.

2) **Little technical and environmental knowledge**: social major concerns are usually related to health, safety and environmental issues, being the most important one the potential emissions generated from waste combustion, especially PDFF.

   Solutions: organize information, communication or even training activities supplying and sharing with the stakeholders a basic knowledge about waste co-processing and how it differs from waste incineration as well as its potential benefits.

3) **Active opposition of NGO's and neighbours:** alarm messages based on health issues are often published by social platforms against incineration and co-processing activities.

Solution:

- To establish a CSR program focussed on local needs and according to each company strategy.
- To promote actively non-formal and informal ESD and awareness raising on SD options.

3.3 ORGANIZATION (WASTE MANAGEMENT)

The development of waste co-processing in cement plants has two main barriers as much as waste management is concerned:

1) **Poor waste market development**: there is little or even no presence of professional waste management companies as well as a shortage of waste treatment facilities, which make landfilling the general treatment.

Solution: proper regulations to encourage waste business development should be taken and fiscal incentives to promote sustainable waste management should be implemented.

2) **Little local cement industry expertise on waste management:** it requires highly qualified experts in the different steps of this activity, beginning with the waste market. These capacities are limited in many developing countries so, not to have the right people in one of the steps could be a bottleneck for the activity. These are the co-processing steps:

- Waste assessment
- Waste analysis
- Logistics
- Setting up the pre-treatment and co-processing facilities
- Operating the equipment

Solution: the strategy on waste co-processing has to be well defined and integrated into the whole company business strategy and all the steps required to achieve this objective such as the improvement of the personnel skills have to be overcome.

3) **Waste availability and competitors**: in countries where incineration of waste plays a major role, waste, which would otherwise be available to the cement industry, is carried to other thermal treatment methods. This can be emphasized by additional market distortions (e.g. subsidies and special energy tariffs for use of waste biomass to generate heat and power).

Solution:

- To balance the development of waste-to-energy to prevent overcapacities and market distortions.
- To investigate the best utilization of waste streams (taking into account the lessons from the implementation of relevant EU policies and optimize their flows).

3.4 ENVIRONMENTAL

1) **Non active environmental policy in the country:** many countries do not have a sustainable development approach, as it is demonstrated with a poor circular economy commitment, no fiscal incentives to sound waste treatment and a poor Administration control of bad practices concerning waste management.
Solution: to develop, strengthen and implement a national environmental policy based on sustainable development principles is the key issue in any country.
2) **No adequate waste available in the market**: the cement industry **needs stable streams of high quality wastes** that can be processed into alternative fuels. The selection of waste fuels is driven by a number of interrelated considerations, including the reduction of emissions (e.g. CO_2, NOx). Often, the local waste industry is not incentivized enough to process the waste to make alternative fuels, leaving the cement industry dependent on industrial wastes and imports only.
Solution: incentivize further development of production of high quality waste, for example, by introducing a legislative framework and increasing the landfill taxes.
3) **Long testing process procedure to get the environmental permit:** in some European countries each waste stream has to be accepted and included in the cement plant permit and, the suitability of each one of these wastes is usually tested through a co-processing trial, where compliance with the Emission Limit Values (when available) and other environmental parameters is checked before using them.
Solution: to have a simple permitting procedure as well as a generic permit to co-process all kinds of suitable wastes without specifying them individually is essential to guarantee co-processing
4) **Incineration or landfill operations**: co-processing activity has a superior environmental performance compared to both incineration and landfill operations. Cement production process is perfectly adequate to treat both hazardous and non-hazardous waste in a safe and environmentally sound manner as there is a complete combustion of organic matter which guarantees very low metals or PCDD/F emissions; however, local governments and municipalities are more reluctant to give permits, especially for hazardous waste co-processing.

Solution: the support and collaboration concerning permit flexibility is a must to push the co-processing activity versus incineration or landfilling. However, prerequisite for this collaboration is the trust of the local authorities that the cement industry carefully observes the environmental standards for sound operations.

3.5 TECHNICAL

1) **New operational requirements** can be also a barrier for the waste co-processing activity. Calorific value has a big importance in the fuel mix changes and, while fossil fuels have a rather standard calorific value, waste streams' values vary very widely so, production process can suffer significant changes. Normally wastes need a pre-treatment in order to provide tailor-made fuels for the clinker process.
   Solution: Quality assurance in the sampling procedure, the sample preparation, the analysis and the external monitoring is required (see the technical specifications of the European Committee for Standardisation, such as CEN/TC 343 'Solid Recovered Fuels').
2) **Change in operating conditions due to the waste co-processing activity**: Process gases have to maintain a temperature of 850 °C for two seconds or, 1 100 °C when using waste with more than 1 % chlorine content.
3) **Solution**: **Install additional environmental equipment to** control emissions and to guarantee full compliance with local environmental regulations and the setting of best practices. **New equipment and alternative infrastructure could be needed** for transport and pre-processing to cement plants. There is a gap in waste management capacities which may be related to infrastructural and logistical issues and / or to lack of organization in the market. Usually, this coincides with underdevelopment in pre-processing facilities resulting into higher share of waste being landfilled and lower share of waste being prepared for the cement industry.
   Solution:
   - To **install new equipment** and establish procedures to adequately segregate materials and generate RDF.
   - To **invest into waste collection**, source separation and waste processing.
   - To **implement more advanced environmental control facilities**: filters, SNCR to reduce NOx and quality control laboratories for waste.
4) **Cross side processes**: wastes with adequate **calorific values can replace fossil fuels** in cement kilns when **they meet certain specifications and characteristics**. There can be cross effects that give rise to a technical or process barrier regarding waste co-processing as they raise difficulties to **integrate alternative fuels installations in the process** (e.g. an AF with low calorific value and a high moisture content will result in an increase of the specific energy consumption per ton of clinker so, in order to **achieve the required energy** demand, it is necessary to use a higher amount of waste fuels compared to conventional fuels). Another example can be related to the co-processing emissions (e.g. high volatile metal concentrations: waste fuels may have an effect on emissions that has to be controlled and minimised by appropriate input control).

Solution: to develop **the own company know-how and to collaborate with specialists on the matter** in order **to solve the technical problems and implement good** practices already proved in other cement plants.

3.6 ECONOMIC

In comparison to the use of fossil fuels, the use of waste in substitution to fossil fuels can reduce operational costs due to the lower cost of energy coming from alternative fuels and the additional income for saving CO_2 emissions. Energy use typically accounts for 30 – 40% of the production costs so fuel is a significant part of the manufacturing cement global cost. Waste fuels are usually less expensive than conventional ones although costs will depend on the type of waste and local conditions, even when waste fuels have to be pre-treated frequently before being fed to the kiln. In many countries, cement plants are paid for using waste fuels, as they give a definite solution to waste management.

1) **Landfilling or incineration treatments are cheaper**: For waste producers co-processing is a cheaper option than landfilling or incineration when these options are penalised in order to respect waste management hierarchy. However, in most of the countries of this study, landfill and incineration are still the preferred options for waste disposal and pre-processing and co-processing activities costs are higher than landfilling fees, which do not take into account the costs of potential ground water contamination or greenhouse gas emissions so cement plants have to pay significant premiums for pre-processed waste. Low landfill taxes and gate fees, along with availability of large landfill capacities do not stimulate utilization of more advanced waste treatment methods so, when these two factors combine, waste which could have been energetically valorised ends up being landfilled.

   Solution: Increase landfill taxes to incentivize advanced waste treatment.

2) **Intangible benefits**: Waste co-processing in cement plants might not be financially feasible on its own, if other larger benefits are not taken into account.

   Solution: Municipalities and governments willing to pursue this activity should design programs or incentives based on the full benefits both for the local community and the environment.

3) **Large investments required**: large CAPEX investments at plant level are required to carry out the fossil fuel substitution so, it is expected that waste co-processing activity brings benefits and added value for the plant.

   Solution: economic incentives to investment in co-processing facilities should be available.

4) **Low price of CO_2 emission rights:** Poor contribution of CO_2 emission saving due to biomass fuels.
   Solution: proactive national policy on GHG emissions reduction.

5) **Low price of fossil fuels:** low cost of traditional fossil fuels discourages the use of alternative fuels**.** However, traditional fuel cost is out of the cement sector's control,
   Solution:
   - To take into consideration not only the fuel cost, but fuel cost + CO2 emissions cost.
   - To negotiate financial advantages for those companies using alternative fuels.

4 EUROPEAN APPROACH TO POLLUTION PREVENTION, CIRCULAR ECONOMY AND LOW CARBON ECONOMY

This chapter makes the link between the waste to energy in the cement industry and the pollution prevention environmental policies which provide the favourable conditions ("prerequisite") for the WtE approach in the cement sector. The EU case is taken as a good practice.

European focus on waste co-processing in the Cement Industry is the result of the EU commitment to a Sustainable Production and Construction model, based on three **assumptions**:

- **Best environmental performance**, as co-processing reduces environmental impacts of traditional cement manufacturing and contributes notably to circular economy.
- **Corporate social responsibility**, as co-processing requires stakeholders' involvement and the improvement of OH&S in the whole management chain.
- **Positive economic contribution to business,** as co-processing reduces cement manufacturing costs.

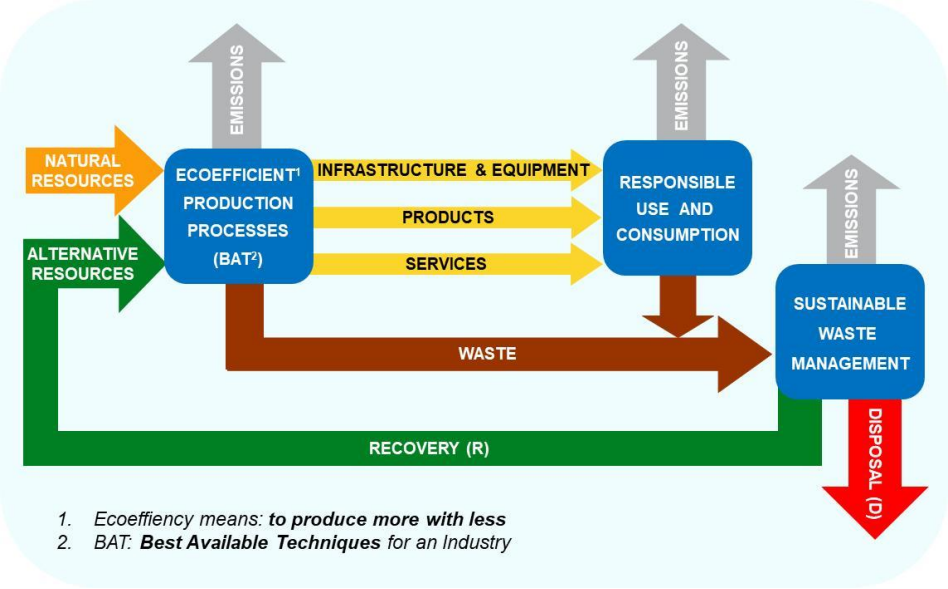


FIGURE 26. GLOBAL EU APPROACH TO SUSTAINABLE PRODUCTION MODEL AND CIRCULAR ECONOMY

The successful development of co-processing in UE is based in three pillars of the environmental European policy which are summarized in Figure 27 and following, they are deeper explained.

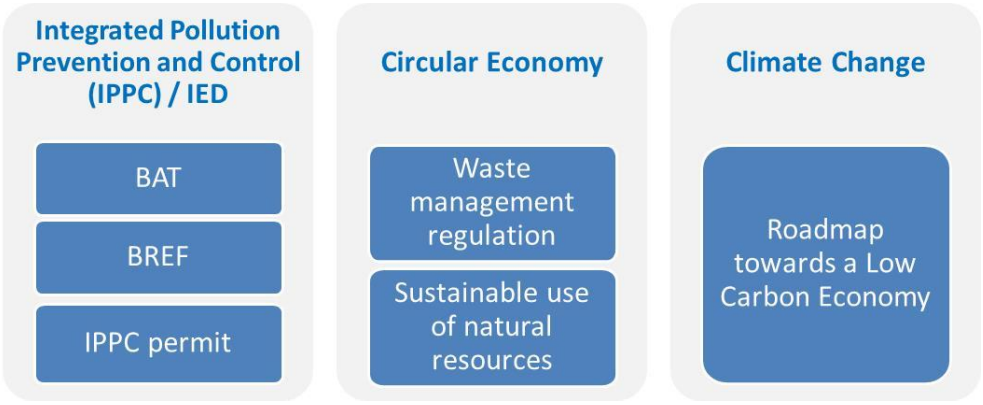


FIGURE 27. MAIN PILLARS OF THE EUROPEAN FOCUS

4.1 IPPC DIRECTIVE. CEMENT AND WASTE MANAGEMENT, BATS AND BREF

EU commitment to control industrial emissions is clearly shown in Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control commonly known as IPPC Directive. This regulation set up the concept of Best Available Techniques (BATs) as "*the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent and, where that is not practicable, to reduce emissions and the impact on the environment as a whole"*. The cement manufacturing process is one within the 33 sectoral industrial processes for which BATs were developed.

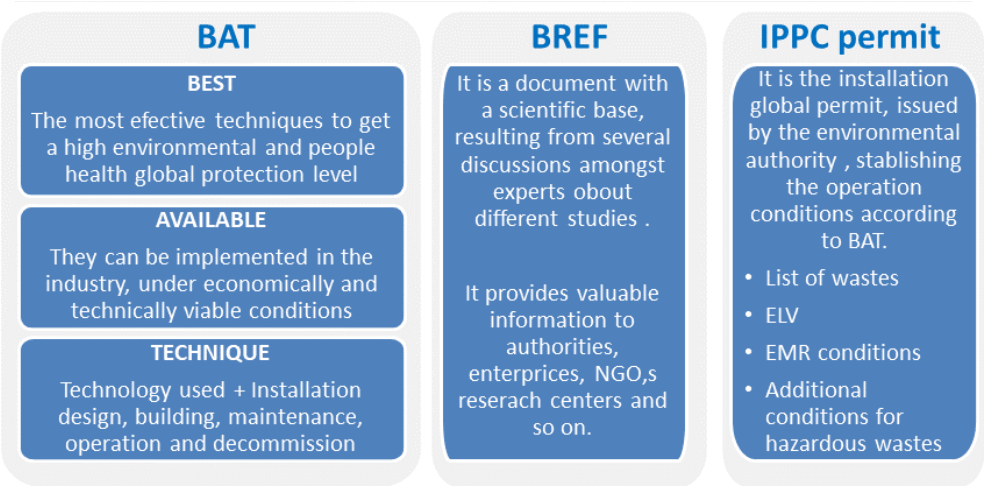


FIGURE 28. DIRECTIVE ON INDUSTRIAL EMISSIONS

As far as waste co-processing in cement kiln is concerned, subject has not been specifically regulated so far and the term has been introduced for the first time in the new Waste Directive adopted in May 2018. Nevertheless waste co-incineration in cement kilns has been widely considered, as energy recovery, for long time by the Directive 2000/76/EC on the incineration of wastes that repealed former directives on the incinerations of hazardous waste (Directive 94/67/EC) and household wastes (directive 89/369/EEC and 89/429/EEC) and replaced them with a single text valid for the incineration and co-incineration of both kind of wastes.

The **Industrial Emissions Directive (IED)** is the present status of the European IPPC approach and sets emissions limit values and monitoring requirements for pollutants to air such as dust, NO_x, SO_2, HCl, HF, heavy metals and dioxins and furans. Besides this directive makes a clear distinction between incineration plant and co-incineration plant, as follows:

- **Incineration plant**. An installation dedicated to the thermal treatment of wastes and may or may not recover heat generated by combustion
- **Co-incineration plant**. An installation, such as cement or lime kiln, steel plant or power plant whose main purpose is energy generation or the production of material products and in which waste is used as a fuel or is thermally treated for the purpose of disposal.

Waste treatments are regulated by the **BREF on waste treatment industries** published in August 2006. Recently, in August 2018 the Commission has stablished the BAT conclusions for waste treatments.

Pre-treatment of wastes to produce AF are under the scope of this BREF, although this is not the case of waste landfilling which is covered by Council Directive 1999/31/EC, recently updated in May 2018, as a consequence of the revised circular economy package of December 2015.

4.2 THE EU CIRCULAR ECONOMY PACKAGE

The EU is committed to a model of Circular Economy as it was shown by issuing in 2014 the Commission Communication “Towards a circular economy: A zero waste program for Europe”. This document sets up that since the industrial revolution, our economies have developed a ‘take-make-consume and dispose’ pattern of growth — a linear model based on the assumption that resources are abundant, available, easy to source and cheap to dispose of. Furthermore, moving towards a more circular economy is essential to deliver the resource efficiency agenda established under the Europe 2020 Strategy for smart, sustainable and inclusive growth. The Commission decided to withdraw the legislative proposal in December 2014 but committed to present a new proposal by the end of 2015.

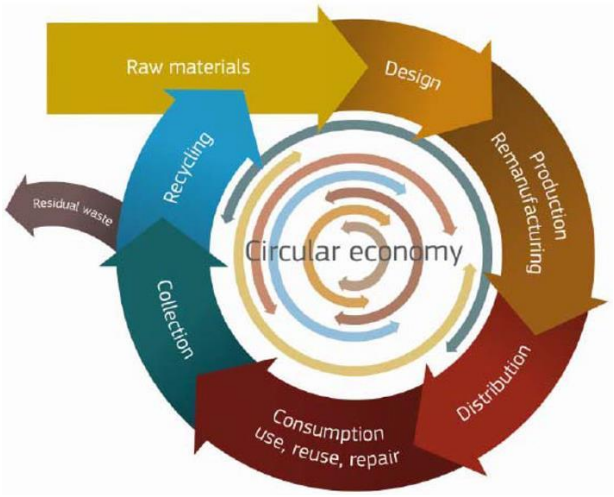


FIGURE 29. TOWARDS A CIRCULAR ECONOMY: A ZERO WASTE PROGRAMME FOR EUROPE. SOURCE: EUROPEAN COMISSION

In December 2015 the EU adopted a new statement on circular economy by mean of the Commission Communication “Closing the loop - An EU action plan for the Circular Economy” that is in fact an ambitious **Circular Economy Package,** which includes measures that will help stimulate Europe's transition towards a circular economy, boost global competitiveness, foster sustainable economic growth and generate new jobs.

The proposed actions will contribute to "closing the loop" of product lifecycles through greater recycling and re-use, and bring benefits for both the environment and the economy. The revised legislative proposals on waste set clear targets for reduction of wastes and establish an ambitious and credible

long-term path for waste management and recycling. Key elements of the revised waste proposal include, among others:

- A common EU target for recycling 65% of municipal waste by 2030;
- A common EU target for recycling 75% of packaging waste by 2030;
- A binding landfill target to reduce landfill to maximum of 10% of municipal waste by 2030;
- A ban on landfilling of separately collected waste;
- Promotion of economic instruments to discourage landfilling.

Furthermore, the action plant on Circular Economy also includes the amending of the current directives on wastes, package and packaging wastes and landfill of wastes.

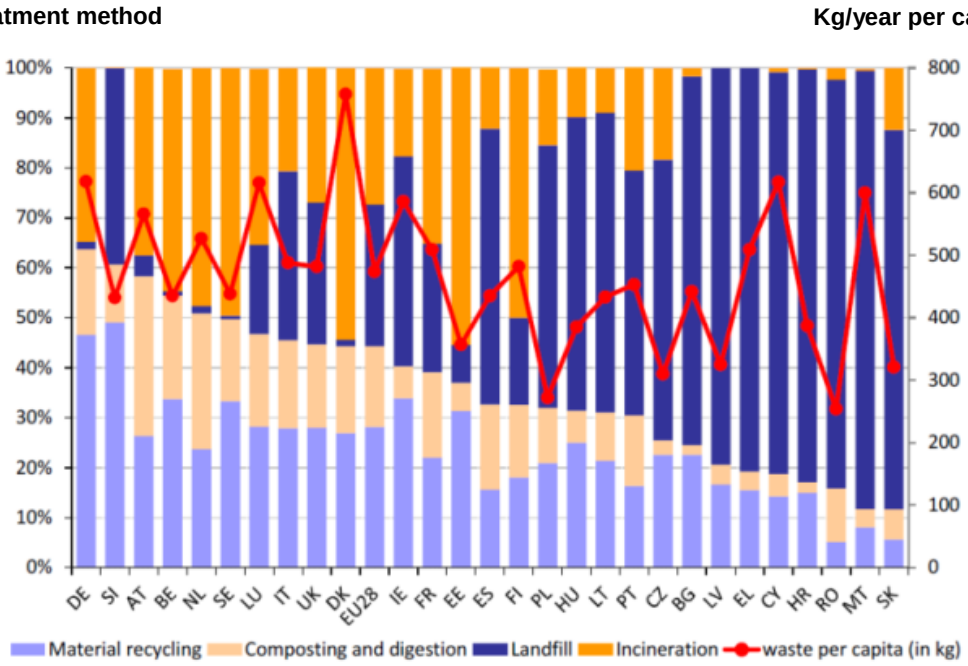


FIGURE 30. MW TREATMENT METHODS AND WASTE PER CAPITA IN EU. SOURCE: EUROSTAT

In 2016, the Commission issued the study “Towards a better exploitation of the technical potential of waste to-energy” elaborated by the Joint Research Centre (JRC), already mentioned in this report. It provides information about waste generation and their treatment, as well as energy recovery data and techniques in the EU, concluding that cement kilns are one of the waste-to-energy processes suitable to enhance the energy recovery from wastes.

In January 2017 the EU issued a report concerning the implementation of the Circular Economy Action Plan that puts emphasis into the role of the waste-to-energy process for the Circular Economy. In fact, together with this report, the Commission is adopting a Communication on waste-to energy processes and their role in the circular economy. The primary objective of the communication is to ensure that the recovery of energy from waste in the EU supports the objectives of the circular economy action plan and is firmly guided by the EU waste hierarchy. The communication also examines how the role of waste-to-

energy processes can be optimized to play a part in meeting the objectives set out in the Energy Union Strategy and in the Paris Agreement.

Finally, in May 2018, the Council adopted the waste package committed by the 2015 Circular Economy Package that includes new or updated regulations:

- Waste Directive
- Directive on the landfill of wastes
- Directive on ELV/Batteries/WEEE
- Directive on packaging wastes

Concerning municipal wastes, new targets on reuse and recycling are:

2025	2030	2035
55%	60%	65%

Moreover, separate collection of textiles and hazardous waste from households targets must be set up by 1st January 2025 and by 31 December 2023 bio-waste should be collected separately or recycled at source generation (e.g. home composting).

Furthermore, in 2030 all waste suitable for recycling or other kind of recovery treatment, in particular in municipal waste, shall not been accepted in landfills. By 2035 landfilling of households waste should be reduced up to 10% of the total generation, at a maximum.

In conclusion, EU considers that it is necessary to establish synergies between energy efficiency policies, resource efficiency policies and the circular economy. When waste cannot be prevented or recycled, recovering their energy content is in most cases preferable to landfilling them, in both environmental and economic terms.

4.3 THE EU ROAD MAP TOWARDS A LOW CARBON ECONOMY

The EU is leading the efforts to prevent climate change within the UN organization. Based on this commitment, in July 2009, the leaders of the European Union and the G8 announced an objective to reduce greenhouse gas emissions by at least 80% below 1990 levels by 2050. In October 2009 the European Council set the appropriate abatement objective for Europe and other developed economies at 80-95% below 1990 levels by 2050.

The Commission adopted in May 2011 the communication “A Roadmap for moving to a competitive low carbon economy in 2050” reconfirming the EU objective of reducing greenhouse gas emissions 80-95% by 2050 compared to 1990 and the industrial sector should contribute with a reduction by 83 to 87%.

This challenging objective will require a huge investment in R&D but also increase the resource efficiency through waste recycling and better waste management.

The high rate of waste landfilling in some countries in the EU would prevent to reach such an objective what represents an excellent opportunity to reduce emissions and safe natural resources.

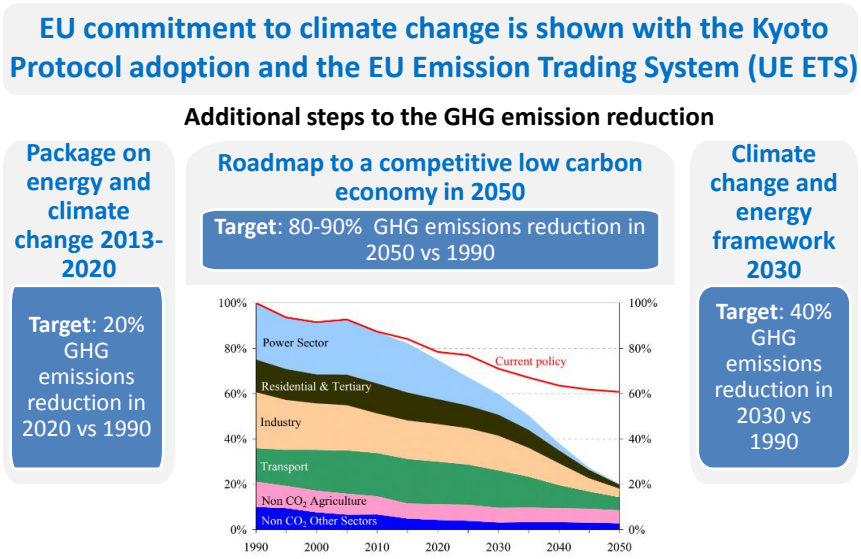


FIGURE 31. THE EU ROADMAP FOR MOVING TO A COMPETITIVE LOW CARBON ECONOMY IN 2050. SOURCE EC

5 PRESENT SITUATION ON WASTE CO-PROCESSING IN THE EUROPEAN CEMENT INDUSTRY

5.1 STATUS OF WASTE CO-PROCESSING IN THE EUROPEAN CEMENT INDUSTRY

Co-processing is a consolidated technique within the EU and other European developed countries, like Switzerland according to Cembureau (*https://cembureau.eu/*) but the development situation differs from country to country. Although all EU countries share a common environmental frame regulation, other factors such as law enforcement, government support, social acceptance or cement sector proactivity are also crucial to develop co-processing at high level.

According to Cembureau, the average co-processing rate in the EU was 41% in 2014. However, the co-processing rates vary quite distinctively between individual countries, depending on a multitude of factors. On behalf of Cembureau, Ecofys (*https://www.navigant.com/news/energy/2019/ecofys-joins-navigant*) has analysed this activity in 14 European countries, in the study "*Status and prospects of co-processing of wastes in EU cement plants*" issued in May 2017. In the following graph, the current co- processing rates along with the expected medium-term and long-term outlook are shown:

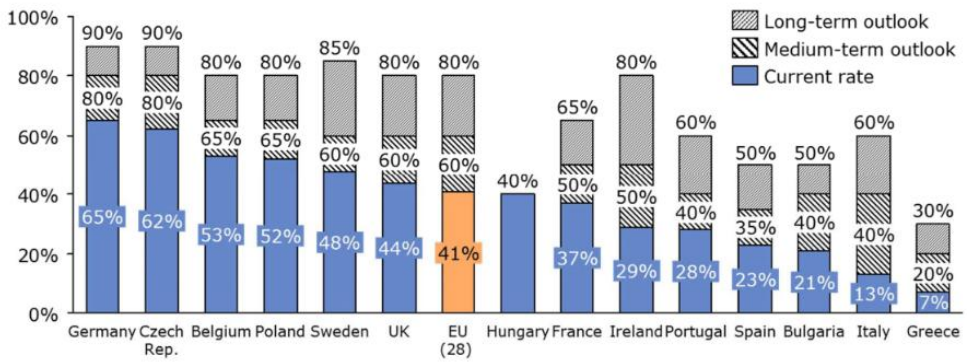


FIGURE 32. CURRENT AND EXPECTED CO-PROCESSING RATES. SOURCE CEMBUREAU - ECOFYS

Less than half of the assessed countries (Germany, Czech Republic, Poland, Sweden, Belgium and the UK) have achieved co-processing rates above the EU average. Hungary and France operate near the EU average. The rest of the countries performed 10% point below the EU average.

The co-processing rate depends on the availability of waste for fuel, so a relation between the maturity of the waste management system and co-processing rates is expected.

For illustrating how co-processing is operating in Europe, in countries with different characteristics and conditions, four case studies have been prepared in order to show the target countries of the present report different scenarios, and experiences useful for their own co-processing development.

Countries have been selected as prototypes that can provide good practices to copy but also challenging situations from which it is possible to learn how to prevent troubles.

CASE STUDY: GERMANY

Germany is a role model as far as waste co-processing in cement plants and waste management are concerned. Co-processing is a mature practice after many years of developing and operation.

Founder member of the European Community and responsible country as far as implementation of environmental regulation is concerned, Germany has almost eliminated waste landfilling and co-processing has been encouraged both by the cement industry and authorities.

Based on VDZ environmental data, the use of alternative fuels in Germany has grown notably since 2003, reaching a thermal substitution rate of 65% in 2016.

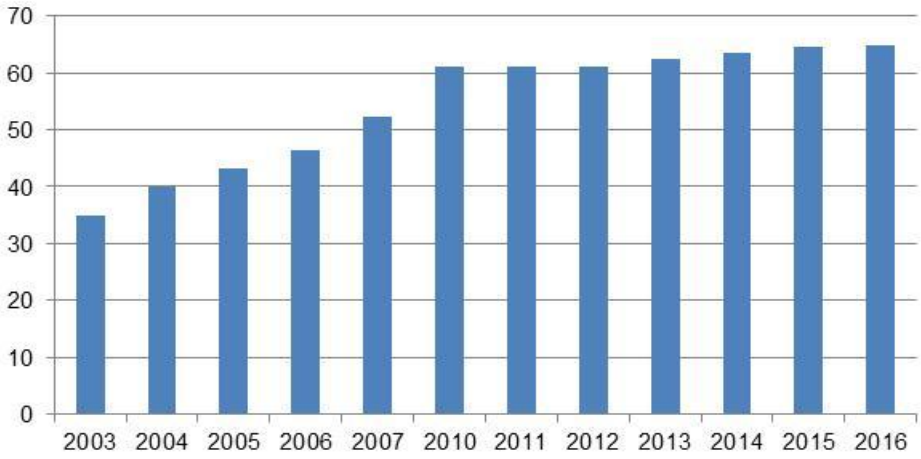


FIGURE 33. THERMAL SUBSTITUTION RATE IN THE CEMENT INDUSTRY IN GERMANY. SOURCE: VDZ

According the ECOFYS study for Cembureau "*Status and prospects of co-processing of wastes in EU cement plants*" issued in May 2017, there are neither social nor technical barriers in Germany against waste co-processing, where the cement sector has a wide experience since long time ago, keeping a high rate of alternative fuel consumption. Waste market organization is well developed and environmental regulation in not an issue at all.

Main global players are present in the German cement sector like Buzzi Unicem, Cemex, CHR, Heidelberg Cement or LafargeHolcim. These companies are also some of the most important players in the target countries for the SWIM and H2020 SM.

AF streams' contribution for years 2015 and 2016 are shown in Table and Figure 34 (*each circle represents the two columns above it, for 2005 and 2016 contributions, identified by colours*).

2005 Contribution		AF type	2016 Contribution	
%	kt		%	kt
20,06	567	**1.- Other industrial and commercial wastes**	**41,14**	1.163
11,45	309	**2.- Plastics**	**24,79**	640
12,61	288	**3.- Waste tyres**	**9,48**	201
5,00	198	**4.- Mixes fraction of MW**	**7,15**	283
4,08	101	**5.- Solvents**	**5,09**	126
10,76	355	**6.- Animal meals and fats**	**4,40**	145
4,18	92	7.- Waste oil	**3,22**	66
1,60	237	8.- Pulp, paper and cardboard	**0,55**	81
0,18	3	9.- Packaging	**0**	0
0	0	10.- Wastes from textile industry	**0,35**	7
0,85	42	11.- Scrap wood	**0,02**	1
0,20	11	12.- Fuller earth	**0**	0
0,79	157	13.- Sewage sludge	**2,34**	463
0,75	28	14. -Other hazardous industrial wastes	**1,47**	58
100,00%	**2.388**	**Total Alternative fuels**	**100,00%**	**3.234**

FIGURE 34. AF FAMILIES ENERGY CONTRIBUTION 2005 (LEFT) AND 2016 (RIGHT).
SOURCE VDZ AND SELF PRODUCTION

Main conclusions:

- Four AF families (non-hazardous industrial and commercial wastes, plastics, waste tires and RDF from municipal wastes) account for more than 82% of the total AF contribution.
- Non-hazardous waste either coming from industry or commerce and MSW represent the biggest opportunity for increasing waste co-processing.
- Waste tires are an interesting steady alternative fuel flow for the cement industry.
- Some traditional AF families (e.g. waste oils, solvents or animal meals) is progressively decreasing due to new alternative management solutions, market concurrency or generation reduction.

Germany is a clear example in implementing European regulations and it could be a good reference to those countries trying to follow the same legislation like Israel and Jordan, but also Albania and Turkey. It is also a good reference for a long term vision on how environmental practices can be developed.

CASE STUDY: SPAIN

Spain is an interesting case study as far as co-processing in the cement industry is concerned. Member of the UE since January 1986, with one of the most powerful cement industries in Europe, upgraded to adapt cement plants to the IPPC requirements, and the presence in the country of all the main global players, the cement industry only has been able to reach a modest level of thermal substitution with alternative fuels accounting for 25% in 2018, only bigger than the other Mediterranean EU countries Italy and Greece and far away from the more advanced European countries in the matter as Germany, Netherlands or Austria.

Industrial sector started the waste co-processing activity in early nineties and, since then, a slow development happened at the beginning, before reaching a moderate speed, not wide enough to get a level according to the cement industry capability and the country possibilities. Lack of regulation enforcement, social opposition by NGOs and neighbours and a weak authorities support, and sometime clear municipalities opposition, were the main reasons for that modest development.

Furthermore, the lack of an early proactive communication strategy, able to get stakeholders engagement since the very beginning, was also an issue. Local governments are responsible for implementing the environmental regulation framework in Spain and a poor common alignment of them on the matter has caused market distortions on the waste management in general and particularly in co-processing.

Although cement sector has done an important effort for the last fifteen years to show the benefits of waste co-processing to society, to train workers in environmental issues and to communicate to stakeholders, co-processing is not completely accepted yet and landfilling is still the main treatment for wastes in Spain. Tolerance with landfilling is hard to be understood, as sustainable waste management treatments are crucial to reach country objectives in Circular economy and Climate change in accordance to EU policies and objectives.

Available information at Fundación Cema, an institution supported by the Spanish Cement Association and Spanish trade unions, shows the evolution of thermal substitution rate with alternatives fuel in the domestic cement sector.

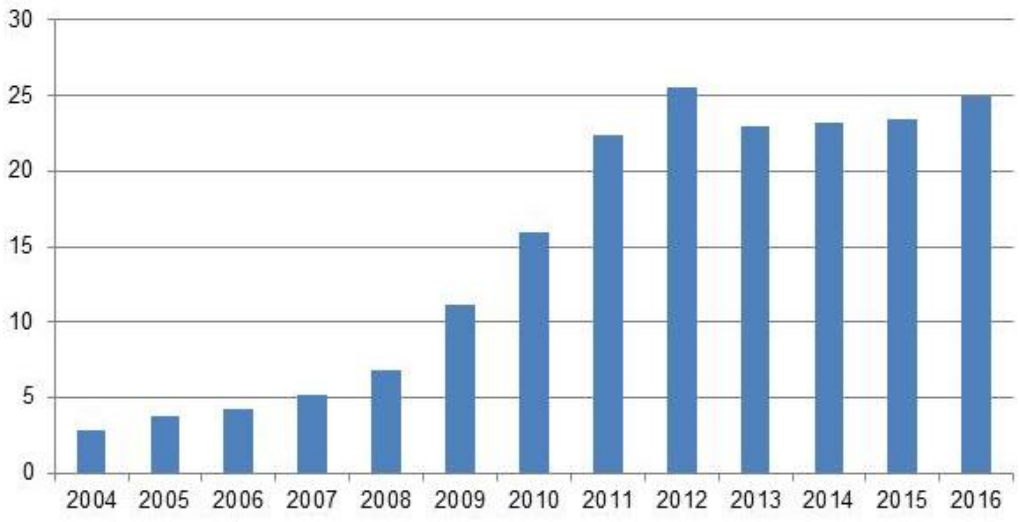


FIGURE 35. THERMAL SUBSTITUTION RATE IN THE CEMENT INDUSTRY IN SPAIN. SOURCE: F CEMA

Main alternative fuels consumed in Spain by the cement industry are: RDF, that has increased progressively its contribution for the last 8 years; waste tires, keeping a steady contribution along the years, animal meals and fats, vegetal biomass, chemical AF liquid and solid that keep an interesting use along the years; Woods and Sewage sludge.

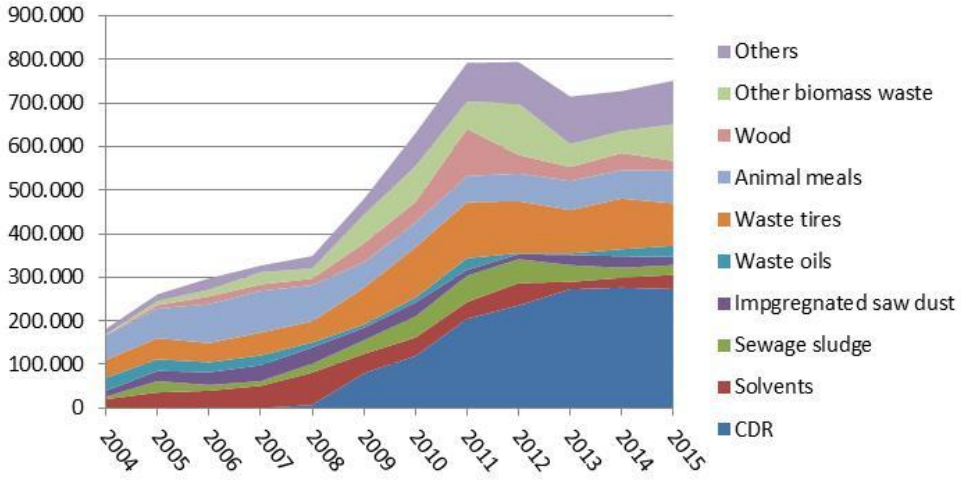


FIGURE 36. AF FAMILIES AND CONTRIBUTION. SOURCE: F CEMA

Main **conclusions** would be:

- Only 2 AF types (CDR and used tires account for more than 50% of the total AF contribution.
- CDR as non-hazardous wastes either coming from industrial and commercial waste and MSW has increased drastically since 2008 and for sure it represents the biggest opportunity for increasing waste co-processing in line with the EU circular economy criteria and the obligation of reducing waste landfilling in Spain.
- Waste tyres are an interesting steady alternative fuel flow for the cement industry In Spain like all over Europe.
- Use of biomass fuels are progressively increasing and will be more important in the next future taking in account the European road map to a low carbon economy.
- Some traditional AF families as waste oil, solvents or animal meals are less and less important although the co-processing capacity for them represent a very positive asset for the waste management infrastructure in the country. In this sense Spain have a very professional pre-treatment capacity mainly for hazardous wastes.

According to a recent ECOFYS study for Cembureau, public acceptance of co-processing is still an issue and there is a poor enforcement of waste management regulations. Although the Ecofys report considers that waste pre-processing in not well developed, Spain has very advance installations for pre-treatment of industrial hazardous wastes into AF and the cement sector is ready to use AF in almost all installations and main global players on MSW management are present in the market, so that the conditioning of MSW into RDF is not a technical issue but an opportunity matter.

Main global payers are present in the Spanish cement sector like Cemex, Heidelberg Cement, LafargeHolcim, or Votorantim, so there are not technical barriers for increasing co-processing. Nevertheless a few cement plants are still under the permitting process due to lack of administration

support or because of social troubles. The main administrative barrier for co-processing in Spain is represented by municipalities, as they have to grant a positive urbanistic certificate that is compulsory for the permitting process and they are reluctant to do so because of the risks of social concern.

The low cost of landfilling represents an important economic barrier that is preventing faster co-processing development while poor enforcement of waste regulation is allowing disposal of wastes that have to be recovered according to more sustainable techniques, as co-processing.

The case of Spain shows that, even a common European regulation, powerful cement industry and good waste management infrastructure are not enough for a high co-processing development except proper law enforcement is also present, through the Administration support, responsible behaviours and social acceptance.

The traditional country culture of tolerance with waste landfilling and the low market cost of this kind of treatment have represented a hard barrier to a more sustainable waste management development, such as co-processing. On the other hand fiscal measurements to prevent landfilling have been barely set up.

Spain is a typical example of EU Mediterranean countries with an advanced EU environmental regulation and strong cement industries with comprehensive know how in the matter, that have not been able to adequately develop co-processing, due to poor law enforcement and active social opposition based on lack of appropriate education/information.

CASE STUDY: POLAND

Poland joined the EU at the beginning of 2004 with a middle size cement industry not well upgraded and a poor development of co-processing. Nevertheless, in less than fifteen years the cement industry has reached a thermal substitution rate of 58% in 2016 (18% biomass), notably higher than the European cement industry, that only reached 39 % according to the GNR information.

The Journal of Cleaner Production 141, 2017 and the Clima East Project, show the fast development of co-processing in Poland and the range of AF streams mainly used to do so. The Polish cement industry got such an impressive success with only a few AF streams and without any significant social problems to accept co-processing.

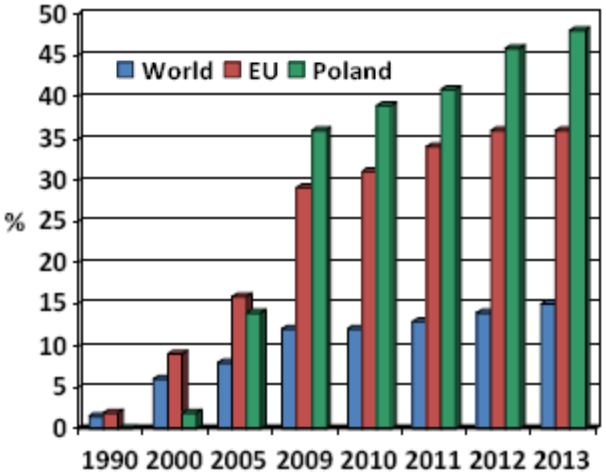


FIGURE 37. EVOLUTION OF WASTE CO-PROCESSING IN POLAND: SOURCE: CLIMA EAST PROJECT

Concerning AF streams the strategy was to concentrate actions on RDF coming from MSW and no-hazardous commercial and industrial wastes and waste tires.

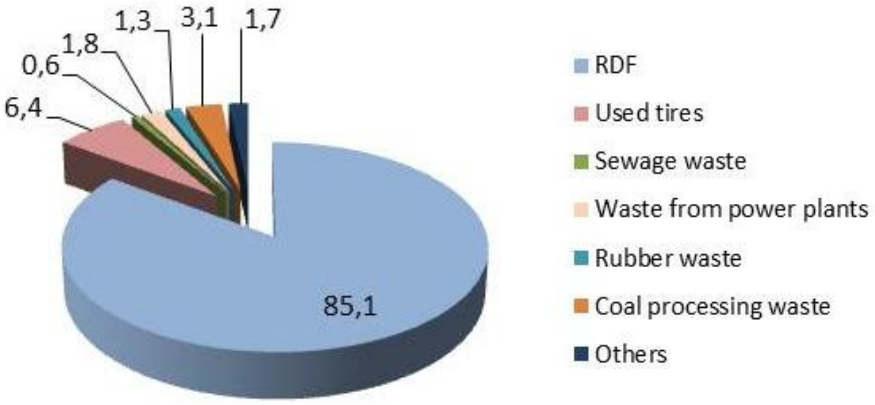


FIGURE 38: MAIN ALTERNATIVE FUELS STREAMS
SOURCE: CLIMA EAST PROJECT

RDF consists of shredded wastes coming from MSW, packaging and commercial wastes, textiles, paper industry waste and similar ones that have been pre-processed in conditioning plants in order to get a quality alternative fuel suitable for the cement industry. Main components of this RDF are:

- Plastics: 35 %
- Paper: 30%
- Rubber: 10%
- Wood: 5%
- Textiles: 20%

Used tires have been used by the Polish cement industry since 2005 and they represent the second most important stream of alternative fuel. **Other streams** of alternative fuels as sewage sludge, blended liquids and others are less important.

Waste incineration has not been developed in Poland as there is a single incinerator plant in operation so far. This means a big opportunity for the cement industry to contribute as a key agent to the national waste management.

According to the ECOFYS study for Cembureau, the development of waste co-processing represents a smart approach at country level to prevent expensive investment in waste management installations by using the present cement infrastructure as essential part of the system.

There are not significant barriers concerning regulations, social or technical issues but AF available do not have enough quality so, **waste pre-processing** is an opportunity to enhance waste co-processing additionally.

Poland uses the National Waste Management Plan (KPGO 2014) to formulate its Policies. The strategy is to reach a thermal conversion bigger than 25% of mixed municipal waste in WtE facilities by 2020 and reduce landfilling of MSW to less than 10% by 2025.

Poland is a good role model for the co-processing development in short time, as a result of a common willing (Government- cement industry) and the society engagement. It represents an exciting experience to follow by economies in transition committed to change drastically the waste management situation taking benefits of the present industrial infrastructure, like the cement industry, instead of investing in sophisticated new installations. Focusing to MSW as the main source of AF is also a realistic approach.

Co-processing in Poland is an example of commitment and opportunities:

- Co-processing is encouraged by Polish government.
- Society considers positively co-processing as a result of government support and sector communication actions.
- The cement sector made its duty improving the industry at the earliest twenties and offering a waste management solution to society keeping a high engagement level with the community.
- MSW has been considered the priority as it represents the biggest volume and the simplest solution. More than 80% of AF contribution is based RDT from MSW.

CASE STUDY: BULGARIA

Bulgaria joined the EU in 2007, so it is one of the last countries in this long European construction process. It could represent a case study for those candidates to enter the EU mainly from the Balkan region as Albania.

In February 2013 the EEA issued a report on the Waste Management System in Bulgaria with a few interesting conclusions:

- In 2010, the rate of landfilled wastes was 98 % of the total generation.
- From 2001 to 2010 no information was reported in MSW recycling.
- It was considered quite difficult that the country could reach European objectives of biodegradable waste landfilling reduction up to 50% in 2013 and 35 % in 2020.
- Landfilling tax has been introduced in 2011 and it seems to grow fast.
- Mechanical biological treatment has been recently introduced in the country and legal framework for waste management is under development.
- In July 2012 the EU Waste Framework Directive has been adopted.
- Total incineration treatment including energy recovery seems to be insignificant until 2010.
- Waste collection reached almost 98 % of the total waste generation in 2010.
- Action priorities in 2010 were to close and to rehabilitate non-compliance landfill sites and to eliminate the irregular dumps.
- In 2011, construction of 23 regional bio-waste composting facilities has started, financed by the Environment Operational Program.

Ecofys study for Cembureau, already mentioned in this report, declares a present substitution of 20% in 2013 and a potential rate up to 50% if there are proper conditions on the waste sector. Nevertheless, situation analysis is quite similar to that one described by the EEA; poor law enforcement, low landfilling taxes and waste pre-processing not developed enough.

Concerning waste generation and management, landfilling accounts for more than 80%; this is a big opportunity to build up pre-processing installations suitable to produce quality AF reducing the volume of wastes sent to landfill and their organic material content, in order to fulfil EU environmental regulations.

Mainly acting on the MSW management, Bulgaria could change drastically its waste management situation, providing AF to the local cement industry where important global player are present.

Bulgaria could be a reference for emerging countries that are willing to prioritize its MSW management as it is the case of most of the target countries of the present report.

5.2 TYPES OF ALTERNATIVE FUELS USED BY THE EUROPEAN CEMENT INDUSTRY

Alternative fuels, including a high proportion of waste products, are increasingly being used and now represent almost a third of all fuels in the EU cement industry. Since 1990 the volume has increased seven times reaching over 7 million tonnes in 2010.

Nevertheless, to increase use of AF, access to waste and biomass must also increase. This will be helped by promoting a better understanding of the opportunities and benefits of co-processing by means of communication and introducing legislation to promote co-processing for appropriate waste materials.

The EU cement industry already uses more than 40% fuels derived from waste and biomass in supplying the thermal energy to the clinker production process. The choice for this AF is typically cost driven; however, other factors are becoming more important as the benefit to reduce CO_2 emission, which are lower than with fossil fuels, or benefits towards society, that can be enlarged if more member states increase their AF share, as there are still large differences between the European Member States.

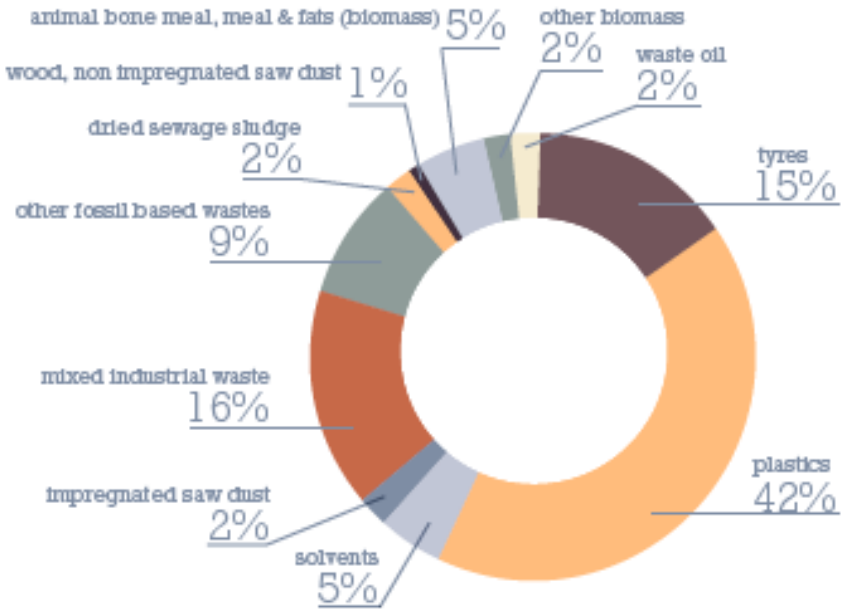


FIGURE 39. ALTERNATIVE FUELS BREAKDOWN 2014.
SOURCE: CEMBUREAU

The European cement industry provides a waste-to-energy solution thanks to the use of waste as a source of energy or a raw material (or both) to replace fossil fuels such as coal, petroleum and gas (energy recovery) and natural mineral resources (material recycling) in industrial processes. According to the latest Eurostat data, 29% of the waste generated in the EU was landfilled, and 13% sent for energy recovery. Of this 13%, the cement industry recovered 9%. In 2014, conventional fossil fuels accounted for 59% of the European cement industry's fuel mix, whilst alternative fuels from waste made up 41%.

Based on a recent study, it has been estimated that the sector has the potential to replace in the medium term up to 60% of its traditional fuels with waste. In future, this figure could even rise to 95%. Making the most of this waste-to-energy capacity has the advantage of reducing the need for additional investment in new waste-to-energy capacity. Member States could save between €9-16 billion by utilising existing capacity in the EU cement industry, an amount that corresponds to investment required for the construction of new waste-to-energy incinerators. The study focused initially on three Member States (Greece, Germany and Poland), and it is now being expanded to 11 other Member States.

As far as waste co-processing in cement kilns is concerned, based on the cumulated experience on co-processing worldwide and specifically in many IPPC permits for cement plants in Europe, available for public consultation, the cement process is suitable to use, as alternative fuels, a very wide range of wastes coming from different origins. *(http://www.juntadeandalucia.es/medioambiente/servtc1/aaio).*

A summary of them, which could be used as a reference for developing new co-processing projects, is shown according to the European List of Wastes in Table 3:

Waste list	Name of waste
01	**Wastes resulting from exploration, mining, quarrying, and physical and chemical treatment of minerals**
01 05 05*	Oil-containing drilling muds and wastes.
02	**Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing**
02 01 02	Animal-tissue waste (animal meals)
02 01 04	Waste plastics (except packaging)
02 01 07	Wastes from forestry
02 02 02	Animal-tissue wastes (animal meals)
02 02 03	Materials unsuitable for consumption or processing (animal grease)
03	**Wastes from wood processing and the production of panels and furniture, pulp, paper and cardboard**
03 01 01	Waste bark and cork
03 01 04*	Sawdust, shavings, cuttings, wood, particle board and veneer containing hazardous substances
03 01 05	Sawdust, shavings, cuttings, wood, particle board and veneer other than those mentioned in 03 01 04
03 03 01	Waste bark and wood
03 03 07	Mechanically separated rejects from pulping of waste paper and cardboard
04	**Wastes from the leather, fur and textile industries**
04 01 09	Wastes from dressing and finishing
04 02 14*	Wastes from finishing containing organic solvents
04 02 15	Wastes from finishing other than those mentioned in 04 02 14
05	**Wastes from petroleum refining, natural gas purification and pyrolytic treatment of coal**
05 01 03*	Tank bottom sludge

05 01 05*	Oil spills
05 01 06*	Oily sludge from maintenance operations of the plant or equipment
07	**Wastes from organic chemical processes**
07 01 01*	Aqueous washing liquids and mother liquors
07 01 04*	Other organic solvents, washing liquids and mother liquors
07 02 01*	Aqueous washing liquids and mother liquors
07 02 03*	Organic halogenated solvents, washing liquids and mother liquors
07 03 01*	Aqueous washing liquids and mother liquors
07 03 04*	Other organic solvents, washing liquids and mother liquors
07 05 11*	Sludge from on-site effluent treatment containing hazardous substances
07 05 12	Sludge from on-site effluent treatment other than those mentioned in 07 05 11
7 05 13*	Solid wastes containing hazardous substances
07 05 14	Solid wastes other than those mentioned in 07 05 13
07 07 03*	Organic halogenated solvents, washing liquids and mother liquors
08	**Wastes from the manufacture, formulation, supply and use of coatings (paints, varnishes and vitreous enamels), adhesives, sealants and printing inks**
08 01 11*	Waste paint and varnish containing organic solvents or other hazardous substances
08 01 17*	Wastes from paint or varnish removal containing organic solvents or other hazardous substance
08 04 09*	Waste adhesives and sealants containing organic solvents or other hazardous substances
12	**Wastes from shaping and physical and mechanical surface treatment of metals and plastics**
12 01 05	Plastics shavings and turnings
12 01 07*	Mineral-based machining oils free of halogens (except emulsions and solutions)
12 01 10*	Synthetic machining oils
12 01 12*	Spent waxes and fats
13	**Oil wastes and wastes of liquid fuels**
13 01 10*	Mineral based non-chlorinated hydraulic oils
13 01 11*	Synthetic hydraulic oils
13 02 05*	Mineral-based non-chlorinated engine, gear and lubricating oil
13 02 06*	Synthetic engine, gear and lubricating oil
13 04 01*	Bilge oils from inland navigation
13 04 02*	Bilge oils from jetty sewers
13 05 02*	Sludge from oil/water separators
13 07 01*	Fuel oil and diesel
14	**Waste organic solvents, refrigerants and propellants**
14 06 03	Other solvents and solvent mixture
15	**Waste packaging; absorbents, wiping cloths, filter materials and protective clothing not otherwise specified**
15 01 01	Paper and cardboard packaging
15 01 02	Plastic packaging
15 01 03	Wooden packaging
15 01 04	Metallic packaging
15 01 05	Composite packaging
15 01 06	Mixed packaging
15 01 09	Textile packaging
15 01 10*	Packaging containing residues of or contaminated by hazardous substances
16	**Wastes not otherwise specified in the list**
16 01 03	End-of-life tires
16 01 19	Plastic
17	**Construction and demolition wastes (including excavated soil from contaminated sites)**
17 02 01	Wood
17 02 03	Plastic
19	**Wastes from waste management facilities, off-site waste water treatment plants and the**

	preparation of water intended for human consumption and water for industrial use
19 05 01	Non-composted fraction of municipal and similar wastes
19 05 02	Non-composted fraction of animal and vegetable waste
19 08 05	Sludge from treatment of urban waste water
19 08 09	Grease and oil mixture from oil/water separation containing only edible oil and fats
19 11 02	Acid tars
19 12 01	Paper and cardboard
19 12 04	Plastic and rubber
19 12 06*	Wood containing hazardous substances
19 12 07	Wood other than that mentioned in 19 12 06
19 12 08	Textiles
19 12 10	Combustible waste (refuse derived fuel)
20	Municipal wastes (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions
20 01 01	Paper and cardboard
20 01 10	Clothes
20 01 11	Textiles
20 01 13*	Solvents
20 01 32	Medicines other than those mentioned in 20 01 31
20 01 37*	Wood containing hazardous substances
20 01 38	Wood other than that mentioned in 20 01 37
20 01 39	Plastics

TABLE 3. EXAMPLES OF POTENTIAL WASTE FOR CO-PROCESSING ACCORDING TO EUROPEAN WASTE LIST

Nevertheless, due to the diversity of ways, sizes and characteristics of these wastes, it is very difficult to use them directly, so **it is necessary to pre-treat them** to get a physical state able to be used in the kiln. The cement process can use as AF only a few flows of pre-treated wastes in proper feeding installations:

Alternative fuel categories	Main streams of AF	Waste list examples
Liquid	Animal fats (biomass)	020203
	Waste oil	130110*; 130205*; 130401
	Used solvents	070104*; 070204*; 070304*
	Blended liquid wastes	140603*, 190208*
Small size solids	Agriculture waste (biomass)	020107
	Dried sewage sludge	190804; 190805;
	Animal meals (biomass)	020102; 020202
	Impregnated saw dust (different hazardous waste)	190302*
Fluff	RDF (Refuse Derived Fuel)	191210; 191212
	Plastics	150102; 170203
Sludges	Oily drilling mud	010501*
	Industrial sludge	050101*; 050103*
Coarse waste	Shredded used tires	160103
	Briquettes	191201,191209*, 191211*,
Bulky waste (lump)	Whole used tires	160103
	Bales	191204, 191208

TABLE 4. TYPES OF ALTERNATIVE FUELS CO-PROCESSED IN CEMENT KILNS

LIQUID AF

Liquid AF are fed to the kiln hotter part where temperature is higher and there are maximum guaranties for the destruction of any hazardous substance, so it is possible to accept in this way AF with significant polluting content always under the acceptance condition fixed in the plant operation permit. Usual acceptance specifications for liquid alternative fuel are shown in Table 5.

Description of the liquid waste acceptance specifications	
LHV (MJ/kg)	>7
Halogen content (expressed as Chlorine)	<2%
Fluorine	<0,2%
Sulphur	<0,5%
Heavy metals	
Cd+Tl+Hg	<100 ppm
Tl	<50 ppm
Hg	<10 pm
Sb+As+Co+Cu+Ni+Pb+Mn+Sn+V+Cr	<0,5%
PCB&PCT's	<30 ppm

TABLE 5. EXAMPLE OF ACCEPTANCE SPECIFICATIONS FOR LIQUID FUELS.

Although these specifications could be used as a reference, variations can be found depending on the plant permit as other factors can influence into the operation conditions like raw material quality or the environmental area conditions.

- **Animal fats**

The ban of animal meats and other products for the animal feed due to the mad cow disease originated a huge volume of wastes that should be destroyed, either by incineration or co-incineration due to health reasons. Animal fats were a second flow in the animal meats production process that had to be also destroyed. This waste is an excellent alternative fuel for the cement industry due to the high calorific value and good quality as fuel. Nevertheless, animal fats require to be managed at high temperature in order to prevent solidification, so transport cubes and storage tanks must be thermally isolated and heated. Animal fat has been an interesting AF stream in Europe, especially during the mad cow disease but probably is not a good opportunity in developing countries.

- **Waste oils**

Waste oils from vehicle and machinery maintenance is a very polluting industrial waste because of the high impact on soil and water and in parallel is an excellent alternative fuel for the cement industry due to the high calorific value and ease management at the cement plant.

Except in France where the co-processing of waste oils is supported by authorities, in Europe, nowadays the use as alternative fuel in the cement industry has decreased drastically in favour of recycling treatments to produce oil bases, but co-processing in cement kiln could be a very good solution for emerging countries where recycling industry is still weak and illegal disposal of used oil is a common

practice. The possible use of waste oil as fuel in boilers or stoves should be ban due to the improper burning conditions and the heavy metal emission risk.

Attention must be paid to possible contamination with PCB due to irregular mix with electric transformer oils, already ban in Europe but possible used in some emerging countries.

The opportunity for waste oil co-processing depends very much on the country regulation. Except there is a compulsory waste oil management procedure, cement industry will have no chance to use this waste as alternative fuel. But on the other hand waste co-processing in cement kilns is a good solution for emerging countries because they are easy to manage by the cement plant due the familiarity with liquid fuels. In fact, co-processing was the first management solution for waste oil in Europe before other treatments were developed for these wastes.

- **Waste solvents**

Spent solvents are one of the easiest AF stream for the cement industry, due to their high calorific value, a quite clean liquid phase and positive economic contribution as they are considered as hazardous wastes and the cement industry provides a waste management solution for them.

Main problems of waste solvents management are flammability, toxicity, mixture compatibility and **chlorine content** that require proper storage installation, designed according to ATEX regulations, OH&S measures for workers and quality control tests at the waste reception.

Waste solvents are typically industrial wastes so their availability depends totally on the country industry infrastructure. The main sources of spent solvents are the chemical pharmaceutical and automobile industries and the manufacture and use of paints, glues, and varnishes.

Although waste solvent availability for cement industry has decreased in EU due to concurrency among cement manufactures and volume reduction in solvent generation waste solvents could be an attractive AF for emerging countries cement industry assuming there are a steady generation in the local industry. Nevertheless, there are important generators that probably have big storage capacity, the cement industry needs local collectors and pre-processing installations able to prepare the quality used solvent AF from small producers.

- **Blended liquid wastes**

Industrial wastes have many different generation sources and they are delivered in different containers as cans, drums or big plastic containers, so it is necessary to pre-treat them in a waste pre-processing installation in order to prepare quality liquid alternative fuel which can be used in the cement plant. The way to do that in a bending operation that produces a homogeneous AF with calorific value and chemical specifications suitable to be used in the cement kiln.

SMALL SIZE SOLID ALTERNATIVE FUELS

- **Agriculture wastes**

Agriculture is a source of interesting AF flows for the cement industry, which could be managed as fine solid materials. Examples of these wastes are: **olive pomace, rice husk**, coffee husk, oil palm husk, cashew nut husk, and **sunflower husk**. The use of vegetal saw dust coming from the **wood industry is also possible** but, in general, it is not economically attractive due to the high price of saw dust for

another uses. Due to the neutral CO_2 emission because of their biomass nature, the higher cost the CO_2 emissions rights has, the more attractive is the use of these wastes.

- **Dried sewage sludge**

Sewage treatment is more and more compulsory all over the world and the sludge wastes produced are more and more difficult to manage, due to the high water content and the increasing restriction in agricultural uses. Drying process is a proper solution to reduce waste volume and to provide additional uses.

Although calorific value of dried sewage sludge is very modest as far as WtE is concerned, co-incineration in cement kilns is interesting because of the recycling of the high mineral component for the clinker production.

Opportunities for using such waste in the cement industry depend totally on the availability of dried sludge, something very common in developed countries, but less frequent in the developing ones.

- **Animal meals**

Animal meal represents the main flow in the treatment of meat wastes from slaughterhouse, butchers and meat industry. Animal meat management in the cement plant requires silo installations in order to prevent health risks due to its powered nature. Main management trouble in animal meals co-processing is a high fat content that could make impossible to storage them and to feed them to the kiln.

- **Impregnated sawdust**

Industrial waste either as solid material or sludge can be conditioned into fine solid AF mixing them with absorbent materials like sawdust producing a hazardous waste with homogenous characteristics suitable to be used al AF in the cement industry. **Chlorine content and heavy metal content** have to be controlled in order to guarantee the acceptance specifications at the cement plant.

Pre-processing of these industrial wastes into impregnated sawdust requires a very professional waste management industry due to the complexity of installations and the high operation risks, mainly fire risk, so it is a current solution in Europe but it is less recommended in developing countries.

FLUFF

Fluff is a low density derived alternative fuel produced from household or commercial waste and it is composed mainly of plastics and papers. Its calorific value depends on the waste stream they are coming from, higher when the origin is packing wastes or commercial wastes and lower when they come from household waste. Car shredding can be also a source for RDF production.

- **RDF from municipal waste**

Household wastes are the biggest possible source to produce alternative fuels for the cement industry and other combustion facilities as co-incinerations plants. Furthermore municipal wastes are considered as non-hazardous ones and are produced all over the world and represent of the biggest environmental problems mainly in developing countries. In addition, municipal wastes are very familiar to everybody, so social rejection for its management is lower than the existing one in case of industrial wastes. Pre-processing of municipal waste to produce AF for co-processing is required but installations are less complex than those required for industrial wastes.

Parameter	Unit	Result
Water content	Mass %	8,3
Dry substance	Mass %	91,7
Ash	Mass %	14,5
Gross calorific value	MJ/kg	22,4
Net calorific value	MJ/kg	20,7
Chlorine total	%	0,86
Fluorine total	%	<0,005
Sulphur total	%	0,14
Biomass content	mass-% DR	50
Emission factor	Mg CO_2/TJ	44
Cd + Tl + Hg	mg/kg	2,7
Sb+As+Co+Cu+Ni+Pb+Mn+Sn+V+Cr	mg/kg	1.147
Total detected PCB	mg/kg	<10

TABLE 6. EXAMPLE OF RDF CHARACTERISTICS

Although the type of alternative fuels used in cement kilns depends very much on the cement company strategy, some companies prefer to use principally RDF from municipal and commercial wastes stead of using hazardous AF coming from industrial wastes.

- **Plastics**

Plastic is one of the main present polluting material of land and sea so, its generation, reduction and proper treatment once they have become wastes is a priority all over the world and mainly in Europe. On the other hand, plastics have a very high calorific value that makes them very interesting as AF.

The source for producing fluff as AF from plastics could be packaged wastes from commerce or industry and construction and demolition wastes. Plastics are also the main component of RDF from MSW but these have been considered under the RDF alternative fuel.

Parameter	Unit	Result
Water content	Mass %	3,74
Dry substance	Mass %	78,31
Ash	Mass %	21,29
Net calorific value	MJ/kg	27,6
Chlorine total	%	0,62
Fluorine total	%	0,02
Sulphur total	%	0,14
Biomass content	mass-% DR	57,1
Sb+As+Co+Cu+Ni+Pb+Mn+Sn+V+Cr	mass-% DR	75,58

TABLE 7. EXAMPLE OF FINE SOLIDS CHARACTERISTICS

SLUDGE

Cement industry can also treat as alternative fuel some type of sludge feeding them directly to the kiln inlet by means of a special pump similar to those used for concrete. As this kind of waste have a very high mineral content, material recycling is even more significant than energy recovery for these AF. Typical examples are oil drilling muds or industrial sludge.

- **Oily drilling muds**

In the petroleum extraction industry, mud commonly produced is composed of oil and soil which is a serious polluting material. The cement industry can use these wastes feeding them to the kiln entrance by mean of sophisticated pumping systems.

- **Industrial sludge**

Petrochemical industry or waste water treatment in industry in general can produce flows of hazardous sludge suitable to be co-incinerated in the cement industry feeding them to the kiln entrance. Due to the high water and minerals content the calorific value is normally quite low and the treatment consists more in a recycling operation than in a energy recovery one.

COARSE ALTERNATIVE FUELS

The cement industry has the possibility of using as alternative fuel coarse material that cannot be pumped or flown into the kiln. In this case the material is mechanically managed and fed to the kiln inlet by means of a conveyor. Shredded tires represent typical examples of these alternative fuels.

Description of the waste and the acceptance specifications	
LHV (MJ/kg)	>7
Halogen content (expressed as Chlorine)	<1%
Fluorine	<0,2%
Sulphur	<5%
Heavy metals	
Cd+Tl+Hg	<100 ppm
Tl	<50 ppm
Hg	<10 pm
Sb+As+Co+Cu+Ni+Pb+Mn+Sn+V+Cr	<0,5%
PCB&PCT's	<10 ppm

TABLE 8. ACCEPTANCE SPECIFICATIONS FOR COARSE FUELS

- **Shredded used tires**

The use of waste tires as alternative fuel in the European cement industry is very important representing the second waste flow after plastics. Waste tires are a perfect example of co-processing as they are very good fuels, due to their high calorific value, but furthermore, they provide an interesting recycling role because of the mineral materials they contain, iron and silica. In addition, because of its natural rubber content, the emission of CO_2 from used tires is partially neutral. The most frequent use of waste tires in cement industry is in pieces after shredding them.

- **Briquettes**

In cases of heterogeneous solid wastes with a well know composition, it is possible to condition them as AF in briquettes suitable to be fed to the precalciner in a similar way than the shredded tires. This practice can include textiles, wood or plastics. The briquette allows softer burning conditions at the kiln entrance that prevent emission picks. Due to the feeding point to kiln, chlorine content should not be high.

LUMP

With the help of special installations is also possible to feed big size elements to kiln entrance of the cement kiln where combustion happens progressively while the element travels along the kiln together with the raw material to the hotter side. The most important waste used as lump is whole used tires when they are available at the cement plant proximity, as otherwise, the high transport expenses will not make cost effective the use. Whole used tires can be used in long kilns, where the temperature at the kiln entrance is not high enough, with the help of a quite sophisticate mid-kiln feeding installation.

- **Whole used tires**

Used tires at the end of their working time are a regular stream of wastes in any country needing a waste management solution, as they are not easy to deal with. Moreover they represent a high potential risk of fire in the irregular dumping sites where they are disposed and accumulated in many countries.

On the other hand used tires have a wonderful calorific value, bigger than coal and they provide iron as raw material for the clinker production, so their use as AF is interesting.

- **Others**

Some other wastes prepared as bales could be also used through the whole tires feeding installation assuming they can produce a regular and progressive combustion at the kiln.

The generation of wastes and thus, the availability of them to be used as alternative fuels in the cement sector, depends very much on the country economy frame but there are at least **three main sources**:

- Agriculture
- Municipalities
- Industry

Agriculture is an interesting field for getting wastes that can be used as biomass fuels with a very positive effect on the CO_2 emission reduction in the cement process. Wastes from the olive oil production, rice nuts or several fruit shells are good examples.

Household wastes, commonly under the responsibility of municipalities, are a continuous and regular source of wastes in all the countries and represent one of the most promising opportunities for a circular economy approach as they are still disposed in landfills in many countries at a very high level. The production of RDF from municipal wastes are very common in UE, mainly in countries with a very high environmental commitment where landfilling of waste has been drastically reduced but is also a very challenging opportunity for developing countries where landfilling and dumping are common practices.

The industrial sector is the main source of hazardous wastes generation and need the support of waste management companies to treat the wide range of generated waste by the sector. Here the cement sector can play an important role as part of the waste management infrastructure of any country.

5.3 EUROPEAN REGULATION APPLICABLE TO CO-PROCESSING

Industrial production processes account for a considerable share of the overall pollution in Europe due to their emissions of air pollutants, discharges of waste water and the generation of solid waste.

On 24 November 2010 EU adopted the Directive 2010/75/EU of the European Parliament and the Council on industrial emissions (the Industrial Emissions Directive or IED) that represents the main EU instrument regulating pollutant emissions from industrial installations and replaced seven existing directives, including IPPC Directive and the Waste Incineration Directive.

The IED aims to achieve a high level of protection of human health and the environment taken as a whole by reducing harmful industrial emissions across the EU, in particular through better application of Best Available Techniques (BAT). Around 50,000 installations are required to operate in accordance with a permit (granted by the authorities in the Member States).

The IED is based on several pillars, in particular:

- **An integrated approach**: this means that the permits must take into account the whole environmental performance of the plant, covering e.g. emissions to air, water and land, generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents, and restoration of the site upon decommissioning of the plant/closure.
- **Flexibility:** the IED allows setting less strict emission limit values, whenever achieving the emission levels associated with BAT described in the BAT conclusions would lead to disproportionately higher costs compared to the environmental benefits.
- **Environmental inspections**: it is a mandatory requirement. Member States shall set up a system of environmental inspections and draw up inspection plans accordingly. The IED requires a site visit to take place at least every 1 to 3 years, using risk-based criteria.
- **Public participation**: the public has the right to participate in the decision-making process, and to be informed of its consequences, by having access to permit applications, permits and the results of the monitoring of releases.
- **The use of best available techniques (BAT):** they are defined at EU level by a group of experts from Member States, industry and environmental organisations. The EU issues a BAT conclusion for every **BREF (BAT Reference Document)** that is mandatory in the permitting process of any installation covered by the IED. For certain activities, like waste incineration and co-incineration plants, the IED also sets EU wide emission limit values for selected pollutants.

Cement manufacturing is included in the IED. Cement plants operate in accordance with a permit granted by the authorities in the Member States where the reference for setting the permit conditions is the BREF and its BAT conclusions, which describe, in particular, applied techniques, present emissions and consumption levels.

The BAT conclusion for the Production of Cement, Lime and Magnesium Oxide was published in March 2013 as 2013/163/EU.

Pollutant substances	ELV	Units	Remarks
Dust	20	mg/Nm^3	Daily average (continuous monitoring)
NOx	500 (3)	mg/Nm^3 (1)	
SO_2	50 (2)	mg/Nm^3 (1)	
HCl	10	mg/Nm^3 (1)	
HF	1	mg/Nm^3 (1)	
TOC	10 (2)	mg/Nm^3 (1)	
NH_3	50 (4)	mg/Nm^3 (1)	
CO	---- (5)	mg/Nm^3 (1)	
Cd+Tl	0,05	mg/Nm^3 (1)	Average values over the sampling period of a minimum of 30 minutes and a maximum of 8 hours (spot measurement)
Hg	0,05	mg/Nm^3 (1)	
Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V	0,5	mg/Nm^3 (1)	
DD/FF	0,1	ng/Nm^3 (1)	Average values over the sampling period of a minimum of 6 hours and a maximum of 8 hours for dioxins and furans (spot measurement)

TABLE 9. EMISSION LIMIT VALUES. SOURCE: IED

(1) These emission limit values shall be calculated at a temperature of 273,15 K, a pressure of 101,3 kPa and after correction for the water vapour content of the waste gases and at a standardised O_2 content of 10 % .

(2) The competent authority may grant derogations for emission limit values set out in this point in cases where TOC and SO2 do not result from the co-incineration of waste (ELV for plants with no co-processing: 400mg/Nm^3)

(3) BAT-AEL is 500 mg/Nm^3, where after primary measures / techniques the initial NOx is > 1 000 mg/Nm^3.

(4) BAT document requires NH_3 continuous measurements whenever SNCR technique is used in the plant.

(5) The competent authority may set emission limit values for CO.

6 CURRENT SITUATION ON THE CEMENT INDUSTRY AND WASTE-CO-PROCESSING IN THE MEDITERRANEAN

6.1 GENERAL OVERVIEW

Although the active Partner Countries of the SWIM-H2020 SM are eight (Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Palestine, Tunisia), the present report includes all the 15 non-EU countries of the UfM. Three among them, do not have local integral cement manufacturing (Mauritania, Montenegro and Palestine) and two of them (Syria and Libya) are suffering a dramatic condition of war/post war situation so they have not been considered in the final scope.

Main global players of the cement industry are very well represented in these countries although local groups are also market leaders in some countries. 150 integral cement plants are operating in the analyzed countries, and two countries are the main producers in the considered region; Turkey, with 52 integrated cement plants ranges the fifth position worldwide and Egypt with **25** integrated installations.

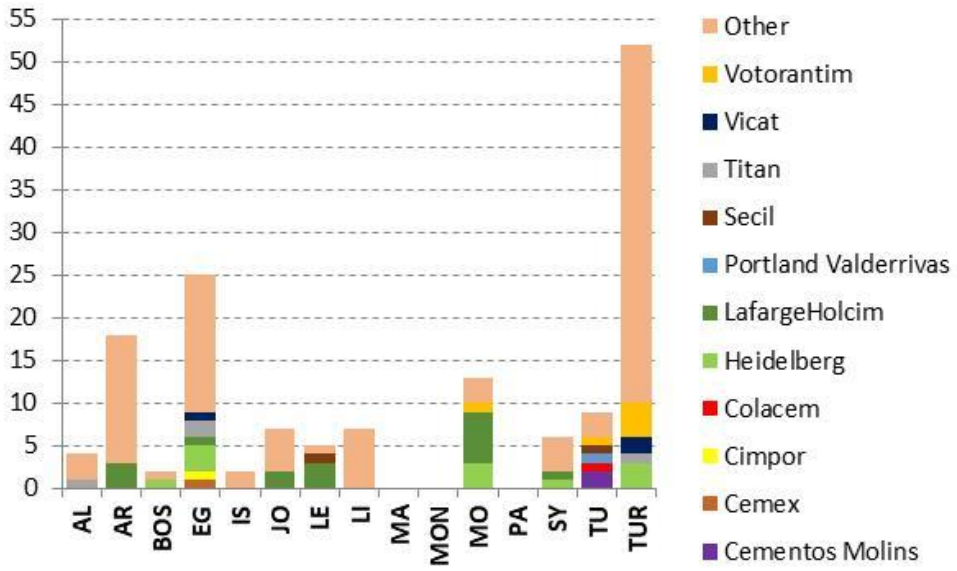


FIGURE 40. INTEGRAL CEMENT PLANTS IN THE MEDITERRENEAN.
SOURCE: GLOBAL CEMENT REPORT 12TH EDITION AND OWN PRODUCTION

Except Israel, strongly committed with waste co-processing, through its local cement industry closely following German standard, waste co-processing has been weakly developed in the region and the waste management situation hardly will allow an easy development of co-processing unless big changes are introduced in this field.

Technical barriers in the cement sector in the region cannot been expected as global cement manufactures with a high expertise in waste co-processing have a strong presence in the region (Heidelberg, LafargeHolcim and Votorantim). Furthermore, other global players with wide experience in waste co-processing are also present at lower level as Cemex, Cementos Molins, Cementos Portalnd Valderrivas, Cimpor, Colacem, Titan and Vicat.

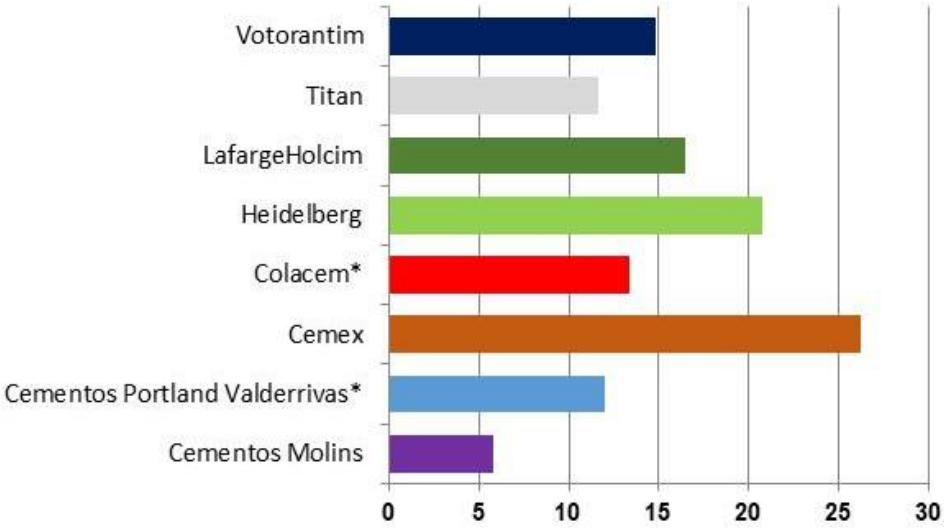


FIGURE 41. THERMAL SUBSTITUTION RATE (%) WITH ALTERNATIVE FUELS IN SOME GLOBAL CEMENT PLAYERS 2017 (*2016 DATA).

As far as waste management is concerned the fundamental point in these countries is the municipal wastes issue, as they represent a huge waste volume what means a serious risks for environment and for health. Thus, co-processing should not be understood only as a positive contribution to sustainability of the cement industry, but primarily as an excellent and cost effective ally for solving the local waste management problems. Accordingly, the report will focus primarily on the MSW issued in each country. Furthermore, some attention should be paid to other waste streams interesting for waste co-processing in cement kilns including toxic and hazardous wastes. Any other additional information on waste streams without interest for the waste to energy process will be neglected.

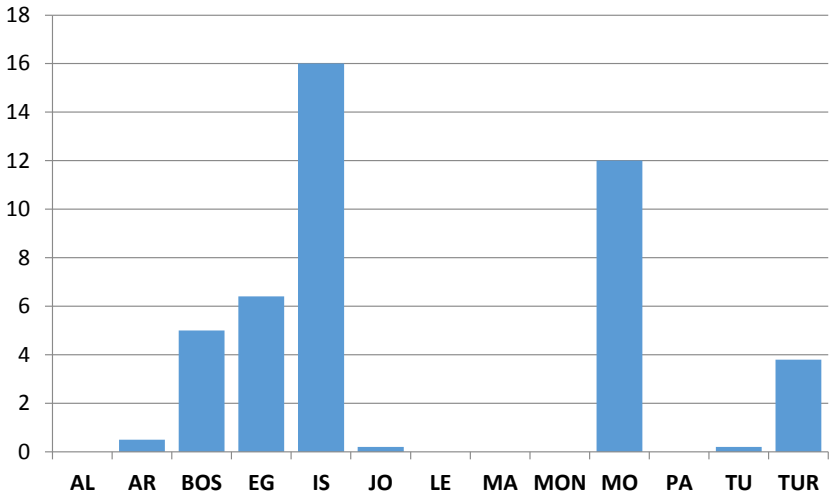


FIGURE 42. THERMAL SUBSTITUTION RATE IN THE TARGET COUNTRIES

The Basel Convention considers that to achieve the prevention and minimization of household wastes and the ESM of them is one of the key challenges related to waste management faced by national governments and municipalities and the public, particularly in developing countries and countries with economies in transition). Based on this, the thirteenth meeting of the Conference of the Parties to the Basel Convention established the **Household Waste Partnership** with the objective of promoting the ESM of household waste. The ESM of household wastes includes, among other things, environmentally sound source separation, collection, transport, storage, recycling, other recovery including energy recovery and final disposal.

The Convention is at present working in a proposal for the development of the Guidance document on the ESM of household waste, which would be useful as a guideline for the countries included in the scope of the present report. Nevertheless, the overarching objective of the Basel Convention is to protect human health and the environment against the adverse effects of hazardous wastes. Its scope of application covers a wide range of wastes defined as “hazardous wastes” based on their origin and/or composition and their characteristics, as well as two types of wastes defined as “other wastes” - household waste and incinerator ash.

The partnership will develop guidance, implementation tools and manuals for governments, regional and local authorities and other stakeholders on, among other things, best practices, business models, policies and innovative solutions for the ESM of household waste in various socio-economic contexts. The Guidance’s aim is to provide inspiration and a decision-making road-map through generic analysis of barriers and benefits of different steps in waste management.

The document will be divided into a series of modules that will provide guidance to practitioners and managers involved in household waste management. The modules will use existing waste management examples to illustrate good/best practice solutions, lessons learned, challenges and barriers to ESM of household waste. The good/best practice ESM should follow the principles of the waste hierarchy – reduce the quantity of waste generated, then maximize the amount that can be reused or recycled, recover energy and disposed.

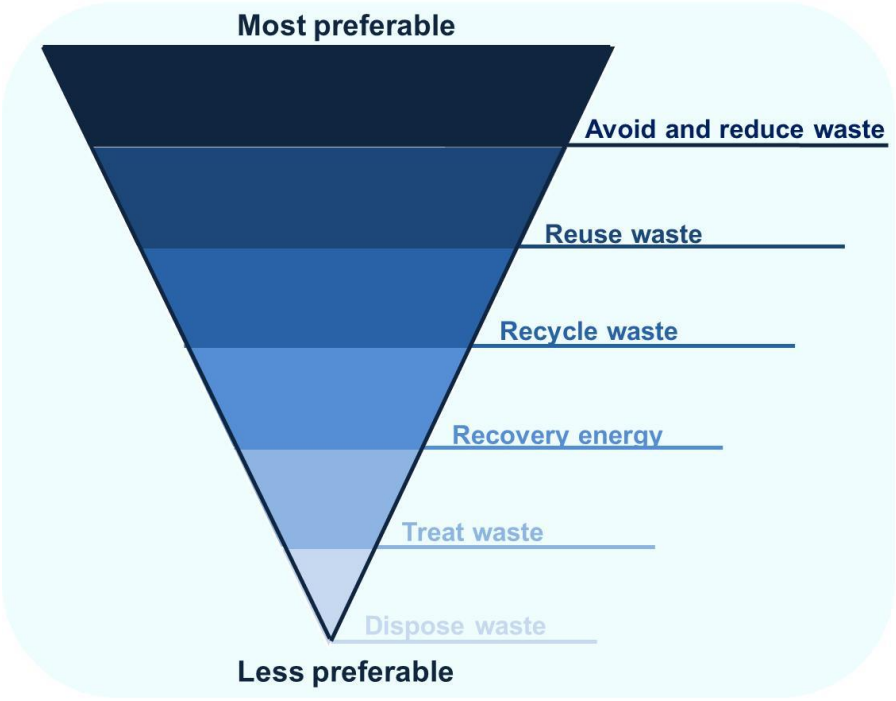


FIGURE 43. WASTE HIERARCHY. SOURCE: BASEL CONVENTION

The guidance should provide tools and techniques for analysis of good/best practices and case studies such as assessment methods, SWOT analysis and barriers and benefits analysis. This is in accordance to the methodology adopted in the present study.

FIGURE 44. SWOT ANALYSIS

Barriers and benefits analysis can be used to understand, for example, the barriers that prevent individuals from changing behaviour (e.g. engaging in waste minimization) and determining what would motivate them to act.

The concern on the MSW management situation on developing and emerging countries and the opportunity for contributing to solve this problem through waste to energy options have been also considered by the GIZ as a general guideline and in specific reports concerning waste managements in different targeted countries.

The GIZ guideline "Waste-to-Energy Options in Municipal Solid Waste Management" makes some recommendations to be taken in account when waste to energy treatments are implemented to solve SW management problems:

- To follow the waste hierarchy, WtE is preferable to disposal but takes a position of low priority in the waste management. So WtE should not prevent waste reduction and takes in account the priority of reuse and recycling, when these options are available.
- High emission standards should be fulfilled, what is a normal regulation requirement for waste co-incineration or co-processing in developed countries and could be used as a reference guideline in countries where specific regulation on the matter has not been developed yet.
- To get the proper information and knowledge on waste quantities and characteristics.
- To implement an efficient MSWM system. WtE will be only possible if there is an efficient collection, transport and management system.
- Some other aspect as financial issues, staff qualification or legal security of investment should be also taken in account.
- Finally, the WtE option should be consider as a part of a wider waste management system.

According to the GIZ guideline, it is to be expected that waste generation rates will increase at least twice over the next twenty years in developing countries. This additional huge volume of waste will represent a serious problem for those municipalities that, nowadays, cannot almost face the present waste management problem. WtE technologies are preferable to waste landfilling but, short time, it seems very difficult that emerging countries can solve their global waste management problem without the help of landfills. Nevertheless, what it is unacceptable it to build up new landfilling without taking in account complementary installations able to provide recovery treatment to waste and accordingly reducing to a minimum fraction the volume of landfilled wastes.

Several WtE technologies have been analysed in the GIZ report to solve the MSW problem in emerging countries as incineration, co-processing, anaerobic digestion for biogas production or capturing of landfill gas, but we consider that only two of them a properly real solutions that can contribute notably to solve the problem. Capturing of landfill gas is only an partial remediation of a bad solution, as the original treatment was the undifferentiated landfilling and anaerobic digestion could be a possible solution for some specific waste streams, but not a BAT for huge MSW volume.

Municipal waste incineration is an expensive solution, both in capex and operation cost, and it is low flexible while co-processing is cheaper and allows changing easily form one AF to another with similar characteristics when a more sustainable treatment is available for the original waste stream.

Rough orientation figures for cost treatment in emerging countries provided by the GIZ report are: 40-80 €/t for incineration and 19-40 €/t for co-processing. Nevertheless, it is necessary to study case by case as the real costs depend very much on several local conditions as electricity cost, fossil fuel costs and other.

MSW is for sure the most serious waste management problems in many developing countries but there are also some other typical waste streams where the cement industry can provide an important contribution like waste oils, waste tires, or some agriculture wastes. In these cases, a step by step approach, based on best standard practices is recommended.

Regulation on co-processing has not been in general locally developed but several countries are in the process of following European regulation on waste co-incineration that has been the environmental rule applicable to this matter. Albania, Montenegro, Bosnia and Herzegovina, Turkey, Israel or Jordan are examples of this situation. Seldom, waste import is allowed in targeted countries an even in these cases only few AF steams, mainly waste tires. In Europe co-processing has little restrictions, as waste import for recovery treatment is allowed. This fact represents a serious barrier for local co-processing development and it is a waste opportunity because in the EU there is excess of RDF as a consequence of circular economy regulation.

Social awareness on waste co-processing is low and communication effort and stakeholders engagement is still not enough.

6.2 WASTE MANAGEMENT AND CO-PROCESSING SITUATION IN THE TARGET COUNTRIES

6.2.1 ALBANIA

6.2.1.1 WASTE GENERATION AND MANAGEMENT STATUS

The EEA issued in April 2013 an interesting report on MWM in Albania, which main conclusions have been summarized, as follows:

- MSW management in Albania is at low level, although situation has improved through the implementation on the National Waste Management Plan 2010-2025.
- A separate collection system for MSW is urgently needed.
- Albania has started to develop new regional landfills according to EU environmental and sanitary standards.
- The challenge was the development of infrastructure for waste management.

The targets of the National Management Plan concerning MSW aimed at recycling composting: 25% by 2015 and 55% by 2020. Furthermore by 2025 aimed at 15% of energy recovery.

The Ministry of Environment, Forest and Water Administration had the responsibility of drafting policies and legislation on waste management and the responsibility of for inspections and control concerning the law implementation. In 2011, the Law 10463 on Integrated Waste Management had been adopted transposing the European Waste Framework Directive (2008/98 EC) and some additional regulations were in course in order to adapt the country to the EU directives.

The waste management sector was quite informal with more 12.000 individual collectors and about 60 different recyclable waste collection companies.

The Commission staff working report document “Albania report 2016”, established that, as regards horizontal legislation, the 2015-2020 cross-cutting environmental strategy had not been approved yet

and the country was at an early stage of building administrative capacity to enforce legislation. Inspection capacity had developed but should be further strengthened.

According to the report, in September 2016, an amendment of the 2011 law on integrated waste management was adopted aiming at further aligning with the EU regulation, including the import of waste, although it was only for recycling purposes. Its implementation requires that Albania develops the necessary infrastructure, institutions and a system for monitoring control and reporting of waste movements.

Waste dumping sites have been mapped throughout the country, pending their closure and reclaiming. Waste segregation is non-existent and waste collection for recycling purposes is largely informal. The institutional capacity to manage waste still remains weak at all levels. Waste disposal remains largely non-compliant with environmental protection standards. Industrial waste management is poor due to lack of investments and weak law enforcement. The national waste management strategy and action plan, approved in 2011 and currently under revision, as well as the regional plans have not been implemented yet.

According to the "Technical Assistance for Integrated Solid Waste Management System for two Selected Municipalities of Albania" carried out by Eptisa in 2017, the Ministry of Environment is the main responsible to develop policies, legislation, implement the national strategy for waste management at country level and monitor its implementation. The Ministry hosts the CIWM (Committee for Integrated Waste Management), which is chaired by the deputy minister of Environment (MoE) with other institutions: the National Environmental Agency (NEA) and the State Environment Inspectorate (SEI).

Later on, the Minister of Tourism and Environment has developed a new integrated waste management strategy for Albania for the period 2018 to 2033 which sets out a comprehensive approach to reforming the waste management system in Albania in order to reflect the EU vision for a circular economy and adapt local capacities to meet this key objective.

The strategy was developed under the expert leadership of Regional Environmental Centre (REC) Albania and was presented for wide consultation in national and international forums, with the participation of high-level national authorities, agencies and partners made possible by the German Development Cooperation.

The Ministry of Transportation (MTI) is responsible for the development of standards, best techniques and treatment infrastructure of municipal and construction and demolition waste. The Ministry has collected the data on municipal and C&D waste. An annual budget is assigned to this ministry, mostly related to finance studies, closure of existing waste dumpsites, construction of new landfills and other treatment facilities.

The Ministry of Urban Development is the third one which has responsibilities in waste management in Albania, related to territorial planning and positioning of landfills and other waste treatment facilities. Ministry of Health, Ministry of Defence, Ministry of Agriculture, Ministry of Energy and Industry and Ministry of Finance, also have responsibilities in waste management issues.

6.2.1.1.1 TYPES OF WASTE PRODUCED IN THE COUNTRY

The EEA report already mentioned provides figures on waste generation in Albania based on Ministry of Public Works, Transport and Telecommunication from 2012: 1,069,094 t of MSW and 326,805 t of CDW

- **Municipal Solid Waste:** about 60 % of household waste contains biodegradable residues, and at least 50 % of them can be composted (organic waste and some paper, cardboard, textiles and various residues). 75 % can be burnt and turned into energy (paper and cardboard, plastics, textiles, and a variety of combustible organic waste).
- **CDW** could be used partially to obtain CDR also but it is not a priority for the WtE process, but it is normally more convenient to focus to a recycling process in order to get recycled construction material.
- **Industrial waste** generation should be also produced in the country although figures have not been found. For sure used tires and waste oil are common standard streams that are present in the country, suitable for a co-processing use in the cement industry.

6.2.1.1.2 WASTE COLLECTION AND TREATMENT

Municipalities are responsible for the waste management activity, cooperating with other municipalities if required, setting up service fees as well as the mechanism for revenue collection and the administration of the waste treatment facilities. Local regulations are not aligned with the law on local self-government, and the responsibilities of the municipalities are not clearly defined.

Waste segregation is non-existent and waste collection for recycling purposes is largely informal. Waste disposal remains largely noncompliant with environmental protection standards and law enforcement is very weak. Landfills and illegal dumpsites are the most common waste treatments, even when legislation is built on the prevention principle. Albania has doubled the amount of waste produced in the last 10 years, and 70% of them are dumped at unregulated sites, without appropriate treatment or any separation at the source. Waste disposal remains largely noncompliant with environmental protection standards. Industrial waste management is poor due to lack of investments and weak law enforcement.

The waste collectors are very selective about which types of waste they take away, removing those ones with economic value and leaving others such as batteries, which can cause harm to the environment. Unfortunately, these informal practices make it more difficult to implement a more efficient and standardized waste treatment system.

Albania is pledging in the next 15 years to achieve the 60 percent recovery and 50 percent recycling of packaging waste, reduce the amount of bio-waste by 70 percent, and recover and recycle no less than 70 percent of all other types of municipal waste, leading to improved soil, water and air protection.

Albania has only 68 percent coverage with waste collection services, and generates around 1.2 million tonnes of waste per year. There are only three sanitary landfills available, which are currently operating with limited capacities. The construction of a regional landfill in the Korça region and a feasibility study for Vlora has started. Albania has approved the construction of two more incinerators in Elbasan and Fier through public private partnerships.

Officials from the MoE said that Tirana residents may pay up to 29€ for every ton of waste sent to the incinerator after its construction. At the moment, current fees paid for waste disposal, hardly cover half of the costs of waste management.

The new strategy will create the proper institutional framework to support the management of hazardous waste, which is currently the weakest and most challenging area of waste management, requiring huge financial resources.

With the existing high level of interest on the part of recycling companies, and the infrastructure already installed for most waste streams, the strategy will guide Albania on a clear path towards better waste management.

A Cooperation Program called “Drinking water, management of hydric resources, sewage and disposal of waste in Albania” is being developed in order to properly implement and finance waste management strategy respecting nature and climate. It has 3 intervention areas:

- Area 1 is focused on the review of the National Strategy on Waste Management, strengthening regulations and capacity development.
- Area 2 tries to implement waste management plans at municipal level working with national and local stakeholders.
- Area 3 will support and involve stakeholders in the new concepts, giving them information and awareness campaigns on waste separation, composting and fee payments.

6.2.1.1.3 PUBLIC AWARENESS

Population is not involved enough in waste management decisions. For example, the concession for the handling of solid waste in the Dutch incinerator plant has not been consulted to the public, submitting the proposal to the Ministry of Energy.

Strategy implementation will require significant efforts on the part of both national and local authorities and will be possible only with the active participation of Albanian citizens and the business sector.

6.2.1.2 ALBANIA CEMENT SECTOR AND WASTE CO-PROCESSING STATUS

The cement industry is expected to pick up with the economic growth in the country.

Albania largest cement producer is Seament Holding, with two cement plants, the largest one located near Tirana. Then, it is Titan Group, which holds 80% of the company in Albania, belonging other 20% to the International Finance Corporation. Last but not least is Colacem which own one plant in Northwest Albania.

Concerning imports and exports, no cement has been imported into Albania in 2015, although there have been some clinker imports.

Group / Company	*Number of plants*	*Cement Production capacity (Million t)*
Seament Holding	2	1,63
Colacem SpA	1	0,5
Titan Group	1	1,5

TABLE 10. CEMENT PRODUCTION FACILITIES IN ALBANIA

Waste co-processing in Albania has not been developed yet and furthermore the Government prioritizes incineration over co-processing. This is the conclusion reached by a 2018 report by the École Polytechnique Fédérale de Lausanne.

A similar conclusion could be got from the Government's tender concerning a waste incinerator for Tirana, in June 2017. This decision has been strongly opposed by social forces.

6.2.1.3 SUMMARY

The information concerning waste management and waste co-processing situation in Albania is summarized in the two following slides:

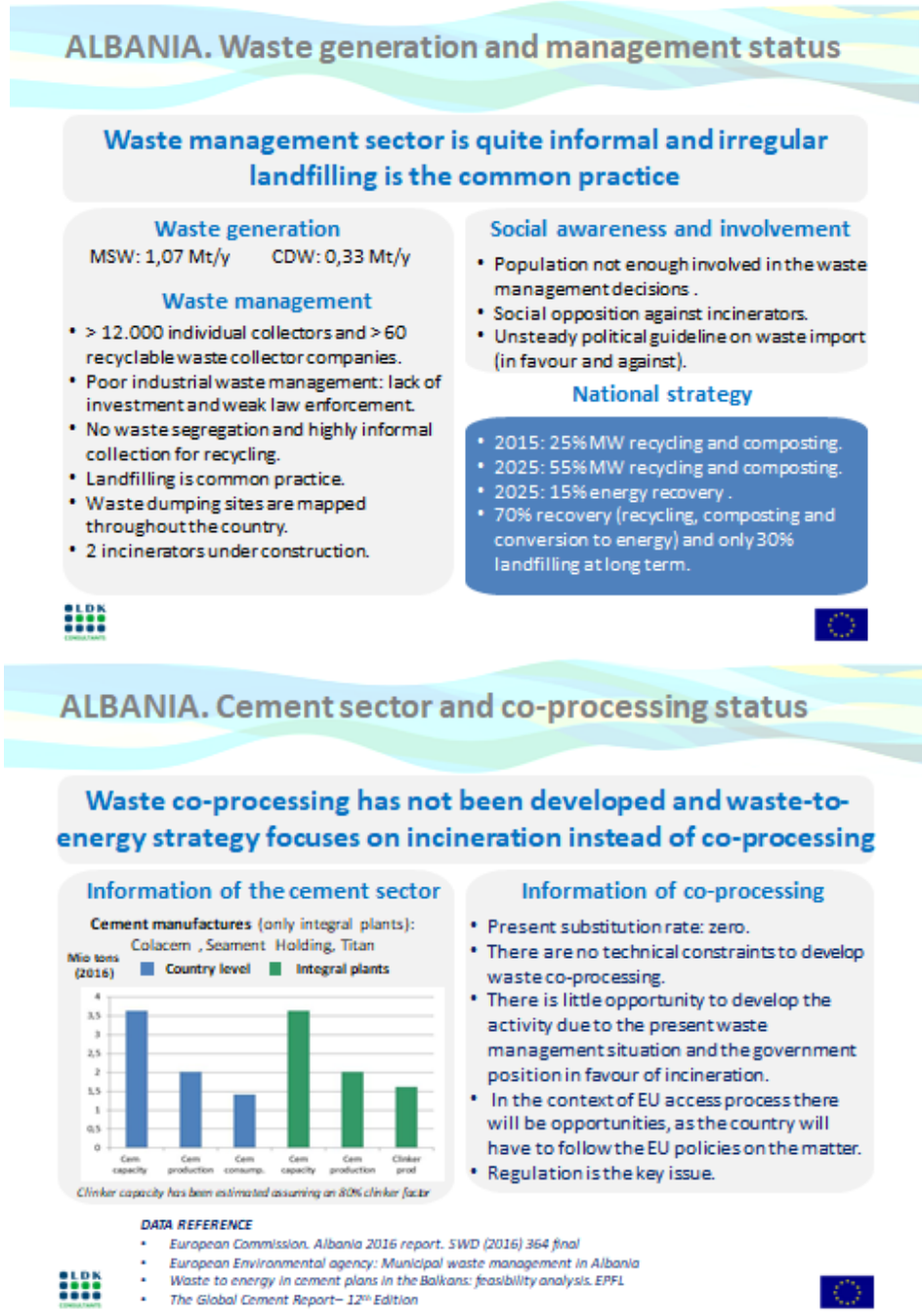


FIGURE 45. SUMMARY OF THE ALBANIAN WASTE MANAGEMENT AND CO-PROCESSING SITUATION

6.2.2 ALGERIA

6.2.2.1 WASTE GENERATION AND MANAGEMENT STATUS

In absence of more recent figures concerning waste generation and management in Algeria, the present report shows the calculations and information supplied by the Dutch Ministry of External Affairs, in the 2018 report on Business opportunities in waste management in Algeria, commissioned by the Netherlands Enterprise Agency, and the report issued by the GIZ in April 2014 on the Solid waste management in Algeria.

Concerning waste management policy and planning there are two national programs in operation:

- National Program of Municipal Waste Management (PRGDEM) in force since 2002 and mainly addressed to local communities.
- National Program for Industrial and Special Waste and Waste from health care activities (PNAGDES).

The institutional framework related to waste management consists of the Ministry of regional Planning and Environment with some specific agencies like the National Waste Agency, and the Ministry of the Interior and Local Authorities providing financial support to municipalities. The participation of the private sector is low except for a few collection and transportation companies.

MSW management is a public responsibility while hazardous waste management is in charge of private partners although there are no local solutions for them. It is planned to build up a treatment plant for special and hazardous wastes.

6.2.2.1.1 TYPE OF WASTE PRODUCED IN THE COUNTRY

- **Municipal solid waste**

Algeria's production of municipal solid waste is around 14 Million tons per year. Due to the urbanisation and growth of population and the economy, this figure will grow to 20 Million in 10 years.

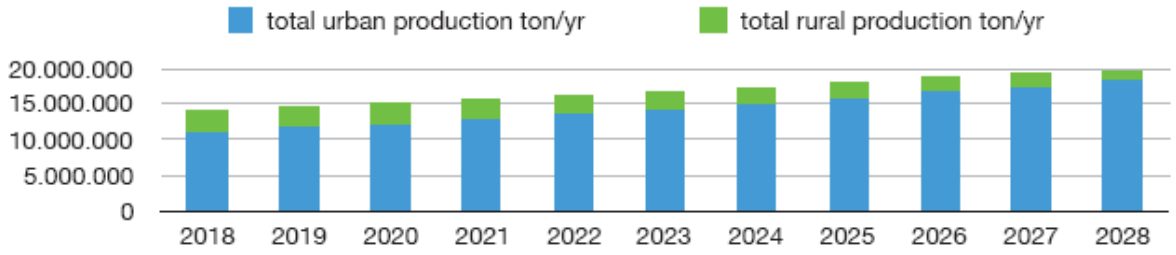


FIGURE 46. EXTRAPOLATION OF ALGERIAN MUNCICIPAL WASTE.
SOURCE: BUSINESS OPPORTUNITIES IN WASTE MANAGEMENT IN ALGERIA. MINISTRY OF FOREIGN AFFAIRS. COMMISSIONED BY THE NETHERLANDS ENTERPRISE AGENCY REPORT OF FINDINGS JUNE 15TH, 2018

According to the GIZ report the composition of WSW in Algeria is: 62.1% organic, 12% plastics, 9,4% paper and cardboard, 1,6% glass, 1,4% metal and 13,5% others.

- **Non-hazardous and hazardous industrial waste**

Estimates on annual production of non-hazardous and hazardous waste add up to 2.550.000 tons of the first ones and 330.000 of the second in 2011. The origin of this waste is:

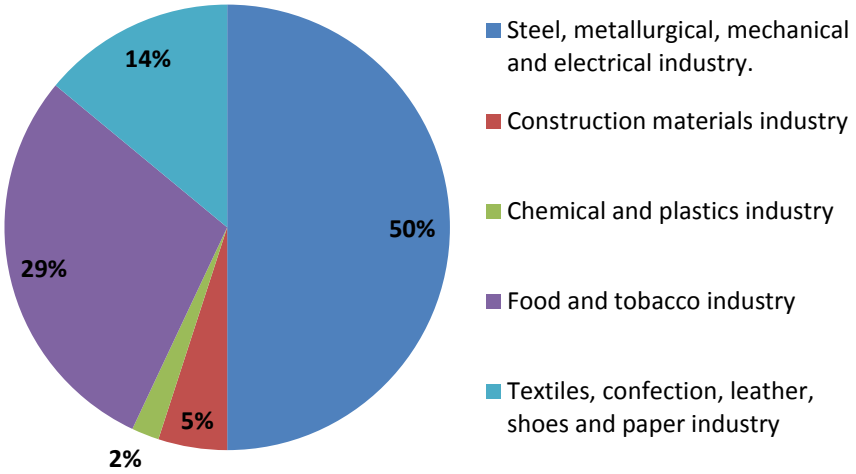


FIGURE 47. WASTE GENERATION IN ALGERIA

Hazardous waste mainly originates from the petrochemical and metallurgical industry and are mostly produced in the eastern regions, which also show large quantities of hazardous waste in stock (>2M tons), awaiting further treatment.

Waste tires and waste oil streams should be mentioned specifically due to the interest for the WtE process. The annual generation of waste tires is supposed to be 26,000 t, which is a low figure compared to the country population. An old stock of more than 135,000t has been estimated.

Concerning waste oil, it has been estimated an annual generation of 110,000 tons only collected by the public company NAFTAL.

- **Construction and demolition waste**

Waste from construction and demolition is around 11 Million tons per year in 2012 according to the GIZ Report, being around 2 or 3 times higher than the municipal waste. This leads to an estimate of more than 30 Million tons per year. Although there are not data available about the composition of this waste in Algeria, it can be said that it holds a huge promise for easy and cheap recycling.

- **Green waste and biomass**

Green organic waste mainly comes from markets and agriculture. It has a potential for bio-treatment so, it is of great interest with regard to its recycling potential. Statistics on its production are lacking but, the World Energy Council provides a figure of around 5 Million tons per year.

- **Waste water treatment plant sludge**

Sludge from wastewater treatment plants is produced at a volume of 2 Million tons per year and it will continue growing up taking into account the plans of the Ministry of water resources.

6.2.2.1.2 WASTE COLLECTION AND TREATMENT

The organisation of the collection and treatment of MSW is managed by the state, municipalities as well as publicly-owned companies. However, collection and treatment of industrial waste is mainly in private hands.

Waste collection seems to have a pretty good coverage of between 85 and 90% in the urban areas, while it does not reach more than 65 and 70% in rural ones. All types of collection are present: door to door by collection trucks, small and larger fixed container sites to bring waste to, small hand carts door to door collection and even donkey powered collection in the steep streets of the Algiers Casbah.

Treatment of MSW is organised on the local level. Depending on the number of inhabitants, each department is equipped with at least one waste treatment centre or a **CET (Centre d'Enfouissement Technique),** which is a reception and treatment (sorting and landfilling) centre for MSW. Since 2002, 79 of such centres have been realised.

In an ideal CET the waste should be weighed, registered and controlled and then, it should be transported to a sorting line. Metals, PET and other recyclables would be sorted out, mainly manually. The residue fraction, consisting for more than 60% of organic, wet waste is landfilled in a controlled landfill, with gas extraction and a treatment facility for leachate water

Unfortunately, many sites are often not constructed as described above. In many cases the CET is just a simple version of a landfill, which size is not aligned with the amount of waste collected, sorting is almost impossible due to the waste characteristics and the fee per ton of waste is too low to cover the costs; furthermore, the number of collectors is insufficient compared to the existing deposits. **The result is that only 8% of the waste is recycled, which is extremely low, while dumping rate is higher than 60%.**

CET's size does not often correspond with the amount of waste collected. Some municipalities open new sites every two years (according to the AND: Agence National pour les Déchets). The fee per ton of waste is too low to cover the costs, with no need to mention investments in recycling technologies. The goal is to reduce the amount of waste, and to recycle much more. According to the AND the focus should be on composting of the organic fraction.

There is no market for energy produced out of waste (gas or electricity) as the national grid is to unstable to accept electricity from decentralised production facilities. Anaerobic Digestion is not an option, because cheap energy is available, and the grid cannot except for the electricity.

MSW landfills are connected to CET's. According to GIZ, 125 new landfill sites are planned in the coming 5 years. The main problem of the landfills is their small capacity so they fill up too quickly. When the program is finished, the country will have 300 controlled landfill sites, which should be enough to receive 75% of the MSW of the country. The amount of waste increases every year and recycling has not really started off yet.

The cost estimates provided by the Ministry of Environment ranges between € 1,60 and € 3,20 per household per month (hhm), which seems a bit on the positive side as, a short calculation for Algiers can be estimated as at least € 4 per hhm, including transport, city cleaning cost, landfilling and overhead.

With the above figures the following **conclusions** can be drawn:

- Current payments of € 0,35 per household /month represent less than 12% of actual costs which is considered extremely low compared to other countries contribution.
- Fees and payments can be related to average and minimum family income. An average household would pay 1% of its income on SWM. The real situation at this moment is however that, in average, not even 0,03% of a family income is spent on this subject.
- Algeria's top-down financing of the SWM system through national subsidies is, in the long term, very unhealthy.

6.2.2.1.3 PUBLIC AWARENESS

The good point is that, at least waste is collected and registered at a central place, which is the first step but, what is really important are the public policies to reduce waste production and to increase waste recycling.

NGOs, such as the **National Conservatory of Environmental Training (CNFE)** have been very active in the field of raising awareness are have been supported by the authorities.

Concerning education, an agreement was signed in 2010 between the Ministries of Environment and Education on environmental education in schools and should cover the entire area of National Education (Primary Schools, Secondary Schools). Some large municipalities begin to implement environmental sections to promote awareness towards the public.

Prodgem programme (Programme National de Gestion Intégré des Déchets Ménagers) has been launched in 2001, with the aim to stop illegal dumping and to organise waste collection in order to keep public health and cleanliness of the cities, to improve the quality of life of the citizens, to achieve save and environmentally sound waste disposal and recycling and to create 'green' jobs. Currently, around 85% of the waste generated in the cities and 65-70% in the rural areas is collected, but there is still a lot to do in this area. A key point would be to **increase the citizens awareness on the importance of living in a clean city**.

6.2.2.2 ALGERIAN CEMENT SECTOR AND THE WASTE CO-PROCESSING STATUS

Despite economic difficulties, cement production has risen **quickly driven by public investment** in housing and infrastructure. This situation has been supported by the construction of new plants and the extension of the already existing ones, **decreasing import dependence**.

Cement production in Algeria has **traditionally been dominated by the state-owned Groupe Industriel des Ciments d'Algerie (GICA)**, operating **12 plants and around 12 Million tons** cement production capacity. These ones account for around **60% local production**, belonging the other 40% to LafargeHolcim Algerie.

Biskra cement is a new player with a 2 Million tons cement plant **operating since 2016**; so are **Sarl Amouda Engineering** with a 2 Million tons in Blida, which **will be operating in 2018** and STG **Engineering and Real Estate Development** with a new 1,5 Million tons plant in Timokten.

Group / Company	Number of plants	Cement Production capacity (Million t)
Cimenterie de Timegtane	1	1,5
Group Industriel des Ciments d'Algerie (GICA)	10	12
Société de Biskria Ciment	1	2
Frères Souakri	1	2,7
LafargeHolcim Ltd	3	10

TABLE 11. CEMENT PRODUCTION FACILITIES IN ALGERIA

Algeria presents a good economic growth at the moment. This means the level of live is also growing and so it is the waste problem. Public Authorities, responsible for the management of MSW, are planning to do significant investments in this field, although they still have a short knowledge about logistical, or governance aspects on waste management. Although there is a general consent that something needs to be done, the first step is to develop proper regulations concerning waste management market and enforce and guarantee compliance of the already existing ones.

Co-processing in the cement industry can provide a perfect option to support this issue and enhance recycling as, on one hand, other waste management operations as composting, are not recommended due to the low cashflow and poor sustainability and, on the other hand, traditional fuels cost is going up but it is still very low to have any economic motivation. The cement sector is mainly interested in waste oils and RDF co-processing.

However, current substitution rate in near zero, being one of the biggest barriers to start up co-processing in the Algerian cement sector for big multinational companies, the need of the Algerian suppliers to team up with Algerian partners. Nevertheless, they are the ones with the higher expertise on this subject so, it would be worth taking them into consideration and try to provide training programs to profit from their Knowledge on the matter.

The opportunity of co-processing should be based on the government commitment to a sustainable waste management and climate change.

One of the most important companies in Algeria, la Société des Ciments de la Mitidj (SCMI, belonging to GICA Group), has started a pilot project using household wastes, waste oils and sludge wastes as alternative fuels [2]. SCMI has carried out the first tests under the surveillance of the Environmental and Renewable Energies Ministry, the local Environmental Authorities and other interested companies, first with pastry wastes conditioned in bags, and then with the injection of 2.000 litres of waste oils and 500 kg of MSW in a successful way, respecting all the environmental and safety protocols and regulations. The second phase of this project, during 2108-2020 will be to have a continuous waste feeding. It will be the starting point for other cement companies within the country and also for the local Authorities to push the co-processing activity as an environmental sound treatment for the waste problem.

2http://www.aps.dz/economie/75859-gica-un-nouveau-procede-de-traitement-des-dechets-de-cimenterie. Publié lundi 02 juillet 2018.

6.2.2.3 SUMMARY

The information concerning waste management and waste co-processing situation in Algeria is summarized in the two following slides:

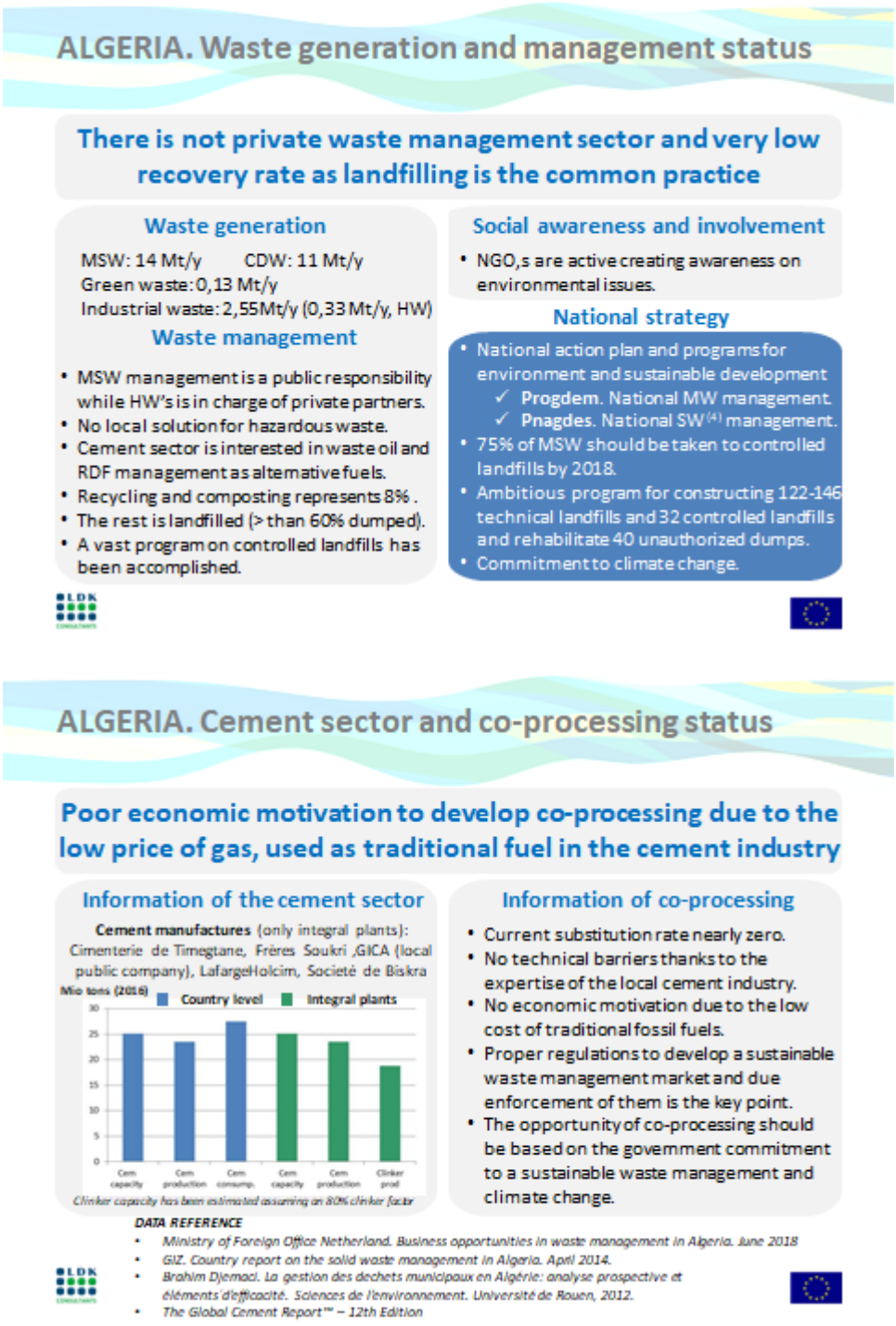


FIGURE 48. SUMMARY OF THE ALGERIAN WASTE MANAGEMENT AND CO-PROCESSING SITUATION

6.2.3 BOSNIA HERZEGOVINA

The country is divided into 3 administrative units/districts: Federation Bosnia and Herzegovina (FBiH) and Republic of Srpska (RS) and Brčko district. Although there are common laws for the country, each division may have its own administrative regulations.

6.2.3.1 WASTE GENERATION AND MANAGEMENT STATUS

The waste management sector is quite informal and irregular landfilling seems to be the common practice, with a rate up to 70-80%. Wastes are not properly separated and, therefore, the recycling rate is still too low (around 5% according to Baswa association data 2015) and neither public nor private waste collection companies are investing sufficiently in this field. Prices for communal services are too low, with a non-sustainable fee collection system.

6.2.3.1.1 TYPE OF WASTE PRODUCED IN THE COUNTRY

- **Municipal solid waste (MSW)**

According to the ECE/CEP/184, United Nations Economic Commission for Europe, Environmental Performance Reviews for Bosnia and Herzegovina (3rd review), unedited draft as of 26 October 2017, data availability on municipal solid waste (MSW) has improved since 2011. At national level, a slight decrease can be seen in the amounts of generated MSW between 2011 and 2015 although between 2013 and 2015 the amount also increased, showing that it is not a stable trend. The amount of MSW generated per capita was 340 kg/person/year in 2011 and 326 kg/person/day in 2015 (around 1,2 Million tons in the country), which was significantly lower than in the neighbouring countries and much lower than the EU average (476 kg). Nevertheless, the volume of MSW collected by the municipalities reached only 0.92 million tons in 2015, as shown in Table 12:

	2011	2012	2013	2014	2015
Total	1.027.006	964.121	881.538	987.546	924.051
Separately collected waste types	98.968	69.679	55,071	58,706	45,369
Rate of separately collected waste	10	7	6	6	5
Garden and park wastes	39,578	46,192	29,685	20,651	22,362
Other municipal wastes	881,978	884,468	775,942	885,443	839,528
Packaging waste	6,482	13,782	20,840	22,746	16,792

TABLE 12. AMOUNT OF WASTE COLLECTED BY COMMUNAL SERVICES IN BIH, 2011-2015 TONS. SOURCE: AGENCY FOR STATISTICS OF BOSNIA AND HERZEGOVINA 2013-2016

The biggest novelty and most significant improvement on waste management since 2011 in the Federation of Bosnia and Herzegovina has been the introduction of the operators system, which aims to contribute to the reduction of waste generation and to ensure that higher level of the concerned waste streams is being recycled or reused.

Manufacturers and the first distributors of the imported goods registered in the territory of the Federation of Bosnia and Herzegovina are subject to the rules and to manage and dispose properly the waste produced by themselves or their products.

The first rules on management of packaging waste were issued in 2011 and became effective in 2012. They have been followed by the rules to manage electric and electronic waste, which became effective from 2013. Both rules had been temporary suspended but have become effective again in April 2017.

- **Construction and Demolition Waste (CDW)**

In 2017, the Agency for Statistics of Bosnia and Herzegovina has published for the first time, the total amount of construction and demolition waste (CDW) for the year 2014. It has been 252,310 tons. About 98.5 per cent of them are mineral waste from construction and demolition and only a small quantity was classified as hazardous waste.

Concerning the three entities in the country, only Republika Srpska published separate data for CDW, which was 428,607 tons for 2014; this means there is a huge and non-conformity gap between the entity level and state level data.

- **Hazardous waste**

Hazardous waste is only measured in the case of industrial activities. The state level data show that production activities generated less than 9,000 tons of hazardous waste. Based on these data, it can be concluded that the current level of hazardous waste production is relatively low in Bosnia and Herzegovina (or either there is a weak control), being the biggest share, in 2014, 66%, from the energy sector (electricity, gas, steam and air conditioning supply).

- **Agricultural waste**

There are no data available of these wastes in BiH.

6.2.3.1.2 WASTE COLLECTION AND TREATMENT

Based on the current rules, operators are not obliged to separately collect municipal waste and they rarely do it, because it is much easier for them to collect the required amount of waste from companies. On the other hand, operators have to fulfil recycling/reuse rates set in the rules.

In the Federation of Bosnia and Herzegovina, the disposal rate of MSW was varying between 94-99 per cent, which reflects the low recycling rates.

Treatment	Tons of waste	%
Permanently disposed on landfill	941.551	98,68
Removal of waste in other way	421	0,04
Recovered waste	12.189	1,28
TOTAL	**954.161**	**100**

TABLA 13. DISPOSED WASTE IN BOSNIA AND HERZEGOVINA IN 2015.
SOURCE: ENVIRONMENTAL PERFORMANCE REVIEWS. BIH. THIRD REVIEW. NEW YORK AND GENEVE 2017

Separate collection in MSW has been gradually introduced in the country during the last years since 2011. The available data on separate collection at national level, which aim was to increase the rate of separate collection and recycling rates, show that the rate of separate collection has however decreased from 10 per cent to 5 per cent, which is confusing; even more when, different areas in the same country show very different figures too.

The predominant method for waste disposal in Bosnia and Herzegovina is landfilling. Between 2011 and 2015, the rate waste disposed on landfills was around 75 per cent. The private sector is dealing with the separation of some materials (at the moment: PET, nylon, steel, paper). The recovery rate was increasing during this period but hardly reached 5% t by 2015.

The differences between the total amount of generated MSW and the total amount of disposed waste show a huge gap, which suggests that about 20-30 per cent of the collected MSW ends up at unidentified locations, most possibly on illegal dumpsites so, the reported disposed amounts of waste is not very reliable either as there is no control of the figures in dumpsites.

Other sort of wastes also shows a very low collection rate. For instance in case of packaging waste target has increased from 8 per cent in 2012 up to 35 per cent in 2016 and in case of electric and electronic waste, it has increased from 8 per cent up to 20 per cent. Operators are obliged to process a certain share of the separately collected waste ranging from 5 per cent to 30 per cent in case of packaging waste and ranging from 50 per cent to 80 per cent and varying by the type of electronic or electric goods.

Concerning **sorting and segregation** of waste, a system based on **operators**, has been implemented in the country starting in the Federation of BiH in 2011 and then in the RS in 2013. The aim of this system is to contribute to the reduction of waste generation and ensure a higher recycling rate. Until June 2017, only packaging waste and WEEE (electronic waste) were involved in this scheme. Manufacturers and distributors of imported goods had to manage and dispose properly the wastes generated by their products. The companies, which are subject to these rules, can fulfil their obligation either by contracting the operators to do the required activities, in order to comply with the rules, or alternatively by paying a (punitive) fine for the Fund of environment. The fees of operators are much more favourable for companies than the taxes to be payed to the Fund of environment, which are more than ten times higher in case of electrical and electronic waste. This encourages the companies to sign contracts with operators. In middle 2017 and amendment of the Law on waste management established similar rules for other waste stream such as batteries, used tires, CDW, sludge, etc. in the Federation of Bosnia and Herzegovina, while in Republica Srpska it will only be applicable to packaging waste and in Brcko District there will be no law regulating this issue.

When talking about **waste disposal or landfilling**, The World Bank has invested in 2009 US$ 39.86 million with the objective to improve the availability, quality, environmental soundness, and financial viability of solid waste management services in participating utilities/regions. The project expected to build six new regional sanitary landfills; establish new districts in the waste management activity; reduce the share of waste not disposed in sanitary landfills; close and rehabilitate 25% of the existing illegal dumpsites; reach a higher citizen satisfaction and increase the cost recovery rate.

According to the Environmental Performance Review carried out by the United Nations (Economic Commission for Europe) in Bosnia and Herzegovina (doc. ECE/CEP/184), the preliminary plans indicated that the country would be divided into 16 regions for the purpose of waste management and all of the regions would have at least one landfill. At the end of 2016, there were already 13 landfills in operation or under construction.

Existing landfills were divided in the following way:

- Federation of Bosnia and Herzegovina: 47 disposal sites in disposal sites in 2015, according to the 2016 Statistical Yearbook of the Federation of Bosnia and Herzegovina, of which only 4 are operating landfills. There were also 340 illegal dumpsites based on the inventory from 2011 (Federal Waste Management Plan 2012-2017). One of the main issues concerning the slow construction of landfills is the difficulty of obtaining the required permits for urban planning / location, environment and construction, as well as delays in obtaining inter-municipal agreements for the establishment of the regional landfills. In parallel to the construction of landfills, old dumpsites have been rehabilitated or closed.
- Republika Srpska : 5 operating landfills in 2016 and more than 250 illegal dumpsites.
- Brčko District: there is not either any operating landfill or under construction.

According to an study on “e-waste management situation and perspectives in Bosnia and Herzegovina” developed by Dr. Mehmed Cero, Ministry of Environment and Tourism of Federation of Bosnia and Herzegovina; Dr. Irem Silajdžić, ENOVA d.o.o. Sarajevo and Dr. Sanda MidžićKurtagić, Mechanical Faculty University of Sarajevo, concerning fees and taxes for waste generation and management, tariffs for households might be based on different factors such as the usable surface, number of waste removals, etc., being the weighted average 51 €/household/year in a family of 3.09 people (Census 2013) and a waste generation rate of 0.8 kg/cap/day. The commercial/institutional sector can be charged per container, with a tariff around 80 €/ton (assuming 185 kg/m³ and 90% filling). Other sources of financing are municipality subsidies, grants from Environmental funds, EPR scheme, and loans by International Finance Institutions like WB or EBRD.

The country is conscious of the problem with waste management and it has stablished the following targets in its environmental policies:

- Achieve the environmentally sound management of chemicals and all wastes throughout their life cycle by 2020.
- Reduce waste generation through prevention, reduction, recycling and reuse.

6.2.3.1.3 PUBLIC AWARENESS

Dumpsites, despite their use by public companies, do not fulfil the elementary conditions for a long term disposal of waste, and they represent an important environmental and health problem, polluting also the soil, the groundwater and the drinking water base. These risks will be also present in the next years, as the closure of dumpsites and landfill rehabilitation is too slow.

There have also been some irregular cases discovered by NGO’s, of some plants operating without the adequate permits or enough controls to develop their activities or start with the new ones.

Awareness campaigns and education projects in the field of waste management (mainly awareness on separate collection and recycling) are being implemented in Bosnia and Herzegovina by NGO’s. Nevertheless, citizens are not really aware of the importance of this issue yet and, at the same time, administrative, legal, economic and technical problems haven’t allowed the proper development of SWM in Bosnia and Herzegovina, making the construction of new regional landfills very slow.

6.2.3.2 BOSNIAN CEMENT SECTOR AND THE WASTE CO-PROCESSING STATUS.

Bosnia Herzegovina cement industry consists of two cement plants with 1,2 and 1,6 Million tons clinker and cement capacity, respectfully.

Lukavac plant is owned by Austria based Asamer Company and Tvonica plant is owned by Heidelberg Cement through its Dutch subsidiary CEEM investment.

Group / Company	*Number of plants*	*Cement Production capacity (Million t)*
Asamer Baustoffe AG	1	0,8
Heidelberg Cement AG	1	0,77

TABLE 14. CEMENT PRODUCTION FACILITIES IN BOSNIA AND HERZEGOVINA

The use of alternative fuels is low, being Lukavac the only plant co-processing waste with a thermal substitution rate around 20% and implementing a new project to increase it to 55%, according Cemreport 12th edition.

Waste co-processing in cement industry is observed as a solution to the waste management problem in the country, as the Prime Minister said during his visit to Lukavac Cement Plant in September 2017.

Furthermore, Heidelberg Cement in cooperation with GIZ are promoting the waste co-processing in the B&H cement industry. In this sense a seminar on the matter was performed at the beginning of 2017.

6.2.3.3 SUMMARY

The information concerning waste management and waste co-processing situation in Bosnia Herzegovina is summarized in the two following slides:

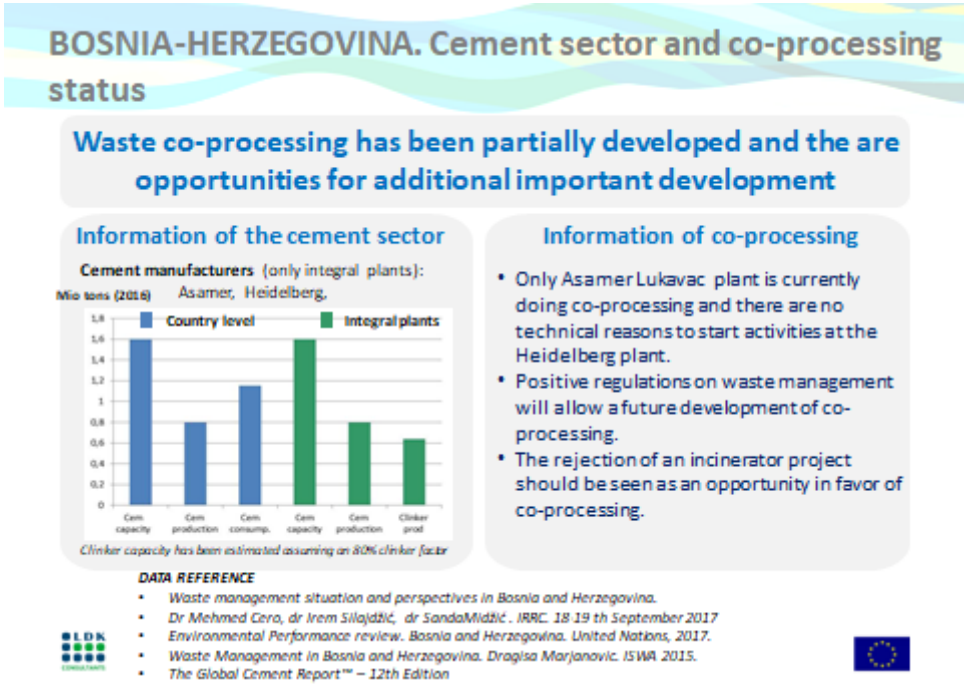


FIGURE 49. SUMMARY OF THE BOSNIAN WASTE MANAGEMENT AND CO-PROCESSING SITUATION

6.2.4 EGYPT

6.2.4.1 WASTE GENERATION AND MANAGEMENT STATUS

Almost 90 million tons of solid wastes were produced in Egypt in 2012, according to GIZ-Sweepnet report 2014, being MSW and agricultural wastes the most significant ones while others, such as construction and demolition waste were generated at lower quantities. Hazardous waste has risen up to a range between 250-500.000 tons.

Although a strategy on solid waste management was released in 2000, in general, solid waste management has been given a low priority in Egypt so far. This is reflected in the limited funds allocated to solid waste management by the government, and the level of services offered for the protection of public health and the environment. Improper solid waste management leads to substantial negative environmental impacts, including health and safety problems such as diseases associated with different forms of pollution. Nevertheless, the international organizations such as the World Bank or the German Development Bank (KfW) have been supporting initiatives for developing strategies and regulation to improve the deficient waste management in the country.

Based on the external support, a National Solid Waste Management Programme (NSWMP) has been commissioned by German Federal Ministry for Economic Cooperation and Development that have been considered by the Egyptian Government. Moreover, the World Bank is also supporting the MSW management infrastructures in Egypt aiming to attract private sector and build sector institutions to deliver environmental services. This approach is consistent with country PPP regulation.

The “new Waste Management Regulatory Agency - WMRA” of Egypt is a new sector institution under the umbrella of the Ministry of Environment. It has the mission to develop the new policy of the Solid Waste Management (SWM) sector, update the national strategy for SWM, draft the new waste

management legislation, lead the investment programs in the waste sector at the National and Governorate level in Egypt, coupled with enhanced professional capacity, and an investment pipeline for implementation of sectoral projects at the regional and local level. This new Solid Waste Agency is intended to take charge of the solid waste sector and to implement the National Solid Waste Management Programme (NSWMP).

6.2.4.1.1 TYPE OF WASTE PRODUCED IN THE COUNTRY

- **Municipal solid waste (MSW)**

MSW represents nearly 25% of the generated solid waste in Egypt, with more than 21 Million tons, being the most critical situation in Greater Cairo, due to the high population, as well as very poor management systems. Waste generation and disposal figures can be unreliable, since there are no weighing facilities at disposal sites and waste are not sampled or analyzed. The total annual municipal solid waste generation in Egypt has increased by more than 36% since 2000.

- **Agricultural waste**

Approximately 30-35 million tons in 2012 of different types of agricultural residues were generated in Egypt (NSWMP, 2013). Half of them have been used by farmers as animal feed, organic fertilizers or for other purposes, and the rest have been disposed of, or burned (El Essawy, 2014).

- **Construction and demolition waste**

CDW generated in Egypt amount to 4,5 Million tons per year. The Egyptian Environmental Law regulated the disposal of CDWs, but did not include any clauses concerning minimization.

- **Industrial waste**

Egypt lacks a specific regulatory and policy framework for industrial waste management. According to the estimates of the Central Department of Solid Waste, Egypt generated about 6 million tons of industrial non-hazardous solid waste in 2012 and around 300,000 – 500,000 tons of industrial hazardous waste in 2011.

6.2.4.1.2 WASTE COLLECTION AND TREATMENT

Currently waste producers do not have a legal obligation to dispose of their waste in a safe and sound environmental way, being compliant with the ‘waste hierarchy’ and the ‘polluter pays principle.’ Egypt does not have a solid waste management law so, the legal framework for solid waste management is established in many pieces of legislation with the corresponding updates (Law No. 38/1967 for General Public Cleaning and Law No. 4/1994 for the Protection of the Environment). Adequate legislation, regulation and law enforcement **concerning waste management should be developed to generate market demand for** environmental and legal waste treatment. This will help to create new business for **AF in the cement industry**.

According to IFC report 2016, the main systems available in Egypt for MSW collection are the municipal services, **local contractors and informal waste collectors, and private companies supervised by the municipalities**. The national average MSW collection rate is around 60% (NSWMP, 2013); less than 20 percent of it, is recycled or disposed of properly. The further availability of RDF will depend on the waste generation and collection rates and mainly on the capacity of waste

treatment plants to produce compost and RDF. It is estimated that 25 percent of total MSW would be converted in RDF.

Concerning SWM, the public sector has not been able to provide the required services, the lack of adequate collection equipment, lack of technical capacities, **very limited existing regulations** and an **inadequate local taxation system**, have become the illegal disposal of domestic and industrial waste, the common practice.

The successful implementation of the national strategy implies the coordination between the Public bodies and all stakeholders involved in the waste management activity, such as the industry, research institutions, community representatives and others.

Here are some concerns about solid waste management in Egypt:

- Less than 60% of the generated waste is operated by public and private sectors, while the rest accumulates on streets and illegal dumping sites.
- Recovery rate does not exceed 11.5%, as more than 80% of the generated MSW in Egypt is dumped.
- There are no clear legal responsibilities concerning solid waste management, as they are **dispersed among more than one structure/ministry** and they do not cooperate between them, approaching the waste management strategy on their own.
- Funds allocated to waste management are very limited. The situation is causing serious environmental problems. The level of street cleanness has deteriorated, and the pollution resulting from garbage incineration has highly increased.

Financing the solid waste management system is a problem, as the revenue from the waste collection fees doesn't cover the expenses needed for a sustainable waste management system and the gap between the available/allocated funding and the actual requirements of the service is increasing.

6.2.4.1.3 PUBLIC AWARENESS

The bad practices disposal of solid waste in waterways and drains has led to the contamination of water supplies, compromising Egypt's natural resources and public health. Public awareness and citizen behavior towards solid waste management was not adequately addressed by the authorities; however, the development of the NSWMP involves the dialogue with different stakeholders and the integration to de sector of relevant players from the private sector and the civil society.

A public private sector partnership (PPP) was created by the Ministry of State for Environmental Affairs to facilitate the operation of huge environmental projects to be implemented with the private sector

A national communication plan in collaboration with the public media has been carried out in order to increase the participation and raise population awareness, especially on hazardous waste. In fact, public awareness campaigns have been organized. In general, people are conscious of the impacts of poor management of solid waste and are willing to contribute to in effective solutions provided by public authorities in addressing, assisting and implementing viable management programs and projects.

6.2.4.2 EGYPTIAN CEMENT SECTOR AND THE WASTE CO-PROCESSING STATUS

Cement consumption in 2015 has been 602 kg per person, which is above the world average, according to the 12th edition of the Global Cement Report, mainly pushed by the Government investments in infrastructures and affordable housing.

Egypt has 25 integral cement plants with a capacity of almost 84 Million t cement and 64 Million t of clinker, some of them belonging to international groups, such as Heidelberg, which is the one with the highest installed capacity, with more than 15 Million tons cement, or LafargeHolcim, which has a single plant with a capacity of 8.9 Million t. Cemex is also present with a capacity of 5.5 Million t cement. There are other smaller multinational companies and several domestic players.

Group / Company	*Number of plants*	*Cement Production capacity (Million t)*
Building Materials Industries Company (BMIC)	2	2.9
El Nadha Cement	1	5
El Sewedy Cement Company	1	2.3
Medcom Cement	1	0.9
National Cement Company (NCC)	1	5,5
Royal El Minya Ciment	1	2
Wadi El Nile Cement Company (WNCC)	1	2,2
Aalborg Portland	1	1,1
ASEC Cement	2	2,6
Cementos La Unión, S.A.	1	5
Cemex	1	5,5
Cimentos de Portugal, SGPS, S.A. (Cimpor)	1	3,9
Egyptian Armed Forces	1	4,4
Helwan Cement Company	1	1,8
Heidelberg Group	3	15,3
LafargeHolcim Ltd	1	8,9
Suez Cement Company	2	4,9
Titan Cement	2	3.4
Vicat	1	3.5

TABLE 15. CEMENT PRODUCTION FACILITIES IN EGYPT

Until 2014, the Egyptian cement industry principally used natural gas but there was a fuel crisis and gradually, subsidies for natural gas have been removed so, natural gas as well as heavy fuel was no longer economically viable and many plants converted to coal and oil as main fuel for firing their kilns.

Because of this issue, the big volume of cement industry in the country and due to the higher CO_2 emissions of coal, the Government started to facilitate the use of AF by the cement sector with the Prime Ministry resolution 94/2015, amending the Decree 338/1995 that developed the Environment Law 4/1994.

Some other institutions as International Finance Corporation (IFC) belonging to World Bank, or the European Bank for Reconstruction and Development (EBRD) have been lately promoting the use of alternative fuels, in order to reduce fossil fuel consumption and CO_2 emissions and increase competitiveness and attractiveness of the cement sector. Strong interest has also raised both in the cement industry and the Government. However, the first step is to develop an adequate waste

management legislation, and law enforcement to generate market demand for sound environmental waste treatment.

The main problem for developing co-processing in the Egyptian cement industry is the lack of availability for waste suitable to be pre-treated to produce RDF and the shortage of pre-treatment infrastructure to produce RDF. Illegal dumping, low efficiency of current waste management facilities, and the lack of enforcement of national MSW strategy are also great barriers.

Nevertheless, in February 2014, a first Egyptian waste processing facility to produce RDF from MSW[3] was opened at Kattameya cement plant belonging to Suez Cement and in 2017 LafargeHolcim announced a waste treatment facility in El Sokhana[4]. These are promising initiatives as the strong presence of the main cement global players in the Egyptian industry is an opportunity to develop waste co-processing because of their strong know-how and commitment to this technique, as the main contribution of the cement industry to sustainability.

In Egypt, waste and biomass derived fuels contribute less than 5% to thermal energy. Waste-to-energy and alternative fuels solutions will not be successful until environmentally sound waste disposal policies will be in place.

The Ministry of Environment's is encouraging a plan to increase in AF use in cement plants to 15% by 2030[5.] This implies the use of nearly 22 Million tons of solid waste and 30 Million t of agricultural waste to produce RDF, used in sectors such as the cement industry.

6.2.4.3 SUMMARY

The information concerning waste management and the waste co-processing situation in Egypt is summarized in the two following slides:

3 https://waste-management-world.com/a/egypts-first-rdf-waste-processing-facility-opened-at-cement-plant

4 http://www.lafargeholcim.com/sites/lafargeholcim.com/files/atoms/files/03272018-press-geocycle-2017-performance-en.pdf

5 https://www.cemnet.com/News/story/160444/egypt-cement-plants-to-use-15-of-waste-by-2030.html

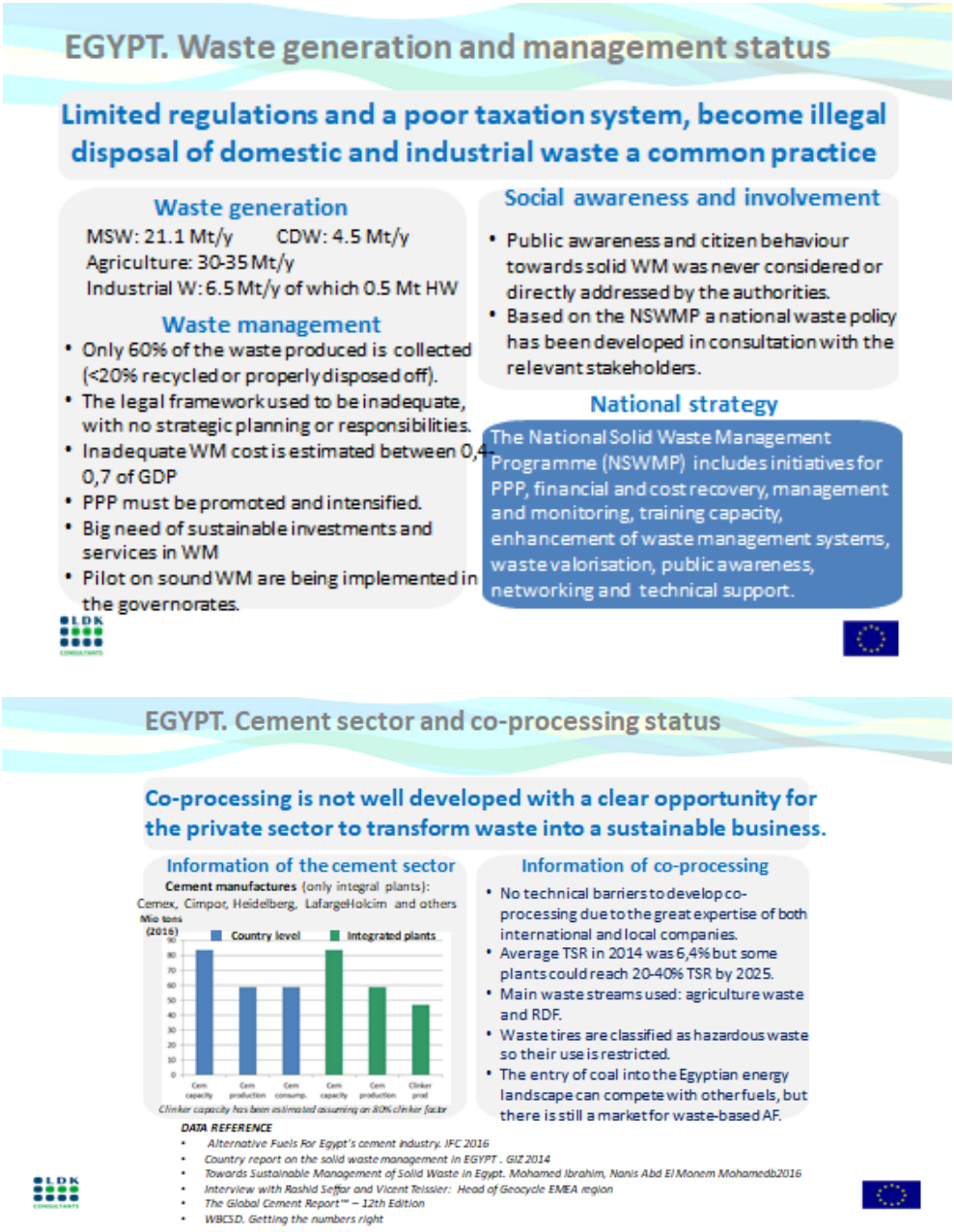


FIGURE 50. SUMMARY OF THE EGYPTIAN WASTE MANAGEMENT AND CO-PROCESSING SITUATION

6.2.5 ISRAEL

6.2.5.1 WASTE GENERATION AND MANAGEMENT STATUS

The available information in the Israel Ministry of Environmental Protection (MoEP) concerning waste management is neither good enough nor updated. Most of the figures correspond to 2012-2013, although they have been issued in 2014.

According to this source, nearly half of the MSW generated in Israel is biodegradable, but most of it is landfilled. In order to shape Israeli legislation and policy towards higher increasing recycling and

recovery rates and reduce the amount of trash landfilled, they must have a clear idea of the amount of waste generated, their composition and final treatment.[6]

Despite a series of initiatives in recent years, only 21% of the country's MSW seems to be recycled, and most of the waste is still sent to the country's overloaded landfills, which are fast approaching maximum capacity. Nevertheless, in the last years new treatment installations have been built up and some of them are able to produce RDF suitable to be used as alternative fuel in the local cement industry as it is the case of the Hiriya treatment plant close to Tel Aviv that is able to produce RDF for Nesher Cement.

According to law, in Israel, municipalities are responsible for collection, storage and disposal of MSW, while the Ministry of Environmental Protection is responsible for establishing waste management policies and developing regulations on the matter. Nevertheless, law enforcement looks to be weak and almost 80% of generated MSW have been landfilled for years. The MoEP helps the municipalities providing funds to build up recycling infrastructure and to raise social awareness on recycling. Furthermore, it also helps municipalities to promote separate collection at the source.

Waste management market was not organized well enough, while the landfilling prices increased drastically without any control

6.2.5.1.1 TYPE OF WASTE PRODUCED IN THE COUNTRY

Israel generates about 5.3 million tons of MSW each year (1.7 kilo per person per day) and it is expected to grow to 6.7 million tons in 2030, being waste production growing at a rate of 2% per year. Furthermore, some 3,7 million tons of CDW were produced in 2012 that are sent to 11 approved landfills for this purpose equipped with recycling facilities for this kind of wastes.

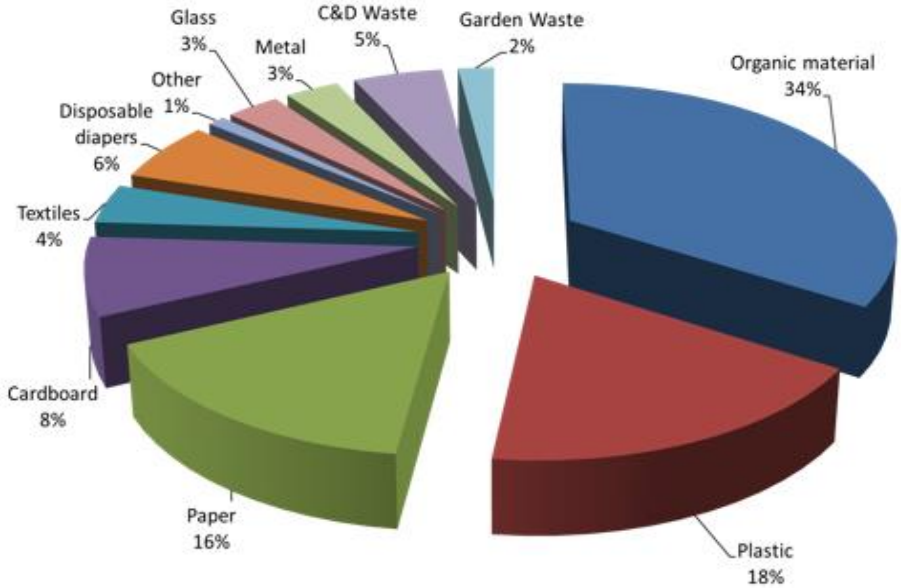


FIGURE 51. SOLID WASTE COMPOSITION BY WEIGHT (DATA FROM 2012 SURVEY). SOURCE: MINISTRY OF ENVIRONMENT

6 Israel of Environmental protection (http://www.sviva.gov.il/English/env_topics/Solid_Waste/FactsAndFigures/Pages/default.aspx)

Every few years, the Ministry of Environmental Protection (MoEP) conducts a comprehensive survey to understand the composition of waste generated in Israel. The results of the most recent survey, conducted in 2012-2013, were published in May 2014 and these are the latest data available at the moment.

6.2.5.1.2 WASTE COLLECTION AND TREATMENT

About **75%** of the total waste produced in Israel is buried in landfills; only about **25%** is recycled, with the following recycling rates per year:

- Organic waste: 12% (0,22 Million tons).
- Paper & cardboard: 34% (0,42 Million tons).
- Plastic: 6% (0.06 Million tons)
- Metal: 250,000 tons per year

The goal is to reach 50% recycling of household waste by 2020.

Concerning the minimization of landfilling and the promotion of recycling and recovery, the top aim of the 2030 plan, sets the following partial targets:

- Reduce the landfilling rate to 26%
- Increase the recycling rate to 51%
- Set the energy **recovery rate at 23%**

Landfilling and disposal remain the main methods of municipal solid waste (MSW) currently. Some 75% of the waste in the country is buried in landfills. As of mid-2013, most of the country's MSW is concentrated into 14 landfills. The major initiatives for development of a more modern MSW management policy, have been the Sustainable Solid Waste Management Master Plan in 2006 and the Recycling Action Plan (2010), which established programs for separate waste collection and recycling for household waste.

Regulation is a key tool for implementing MSW management strategies and plans and this is the responsibility of MoEP.

It promoted and supported separation at source of waste along with materials recovery facilities (MRF) and recycling plants while at the same time enforcing extended producer responsibility laws and encouraging changes in consumption behaviour patterns. However, the results were slow to come. For the past 12 years, about 80% of the MSW in Israel has been landfilled and recycling rates have not increased, despite regulations. Only 25% of the country's municipal solid waste is recycled.

There are 13 approved landfills for municipal solid waste in Israel, most of them in the south and north of the country. It is estimated that the existing landfills will reach their capacity by 2024.

A breakthrough was reached on January 2nd, 2018 when the National Planning and Building Board, Israel's top planning body, adopted the MoEP's Waste-to-Energy policy guidelines.

On January 7th 2018, the **MoEP's Maintenance of Cleanliness Fund approved a budget for the new waste management strategy**. The Fund's administration, including representatives of the MoEP and Ministry of Finance as well local governments, agreed the budgetary framework, paving the way for the implementation of the **12year strategy that is expected to bring about a dramatic change in the waste market in Israel by 2030**. The new strategy is based on a mix of waste treatment

technologies including materials recovery facilities, anaerobic digestion facilities for the treatment of biodegradable waste (that makes up some 35% of municipal waste), and WtE facilities.

The budgetary framework approved for implementation of the waste strategy totals NIS 3.99 billion (nearly $1.2 billion) by 2030, including:

- **Waste-to-Energy facilities:** three facilities nationwide, each of which will treat 1,000-1,500 tons of waste per day. The MoEP will allocate NIS 2.8 billion.
- **Biodegradable waste treatment facilities:** four facilities nationwide that will handle approximately **600 tons of waste per day**. The MoEP will allocate NIS 400 million.
- **Materials recovery facilities:** six facilities nationwide, each of which will handle 1,500 tons of waste per day. The MoEP will allocate NIS 240 million.

Without the construction of WtE facilities over the coming decade, Israel will have difficulties in achieving its landfill target.

At the end of 2015, the Ministry of Environmental Protection has created a **Price Control Committee**, to examine municipal waste handling and price supervision, finding several indications of a kind of "monopoly" in the municipal waste market, as the landfilling prices have risen by as much as 100% at several landfills over the years, with very significant differences in landfilling prices, depending on location, a severe lack of competition amongst those who provide transfer station and landfill services and excessive profits for businesses that deal with municipal waste.

6.2.5.1.3 PUBLIC AWARENESS

According to the article published in the Israel Environmental Bulletin Vol44/Mar2018, despite subsidies aiming to support the establishment of materials recovery and recycling plants in Israel, only one materials recovery facility has been opened in Jerusalem in 2015. The lack of certainty concerning the daily delivery of sufficient waste volume and therefore, the economic viability of such plants has proved to be a major impediment to some of them. However, things are about to change with the **establishment of regional municipal clusters, voluntary corporations established by local authorities**, **with support from the Ministry of the Interior**. The aim is to promote regional cooperation between neighbouring local authorities in the periphery, improve services for residents, and narrow socio-economic gaps as well as to bring economic and social advancement to the region.
On average, **each cluster is made up of about a dozen local authorities, including municipalities, local councils and regional councils,** which are heterogeneously diverse in terms of their socio-economic and demographic characteristics. Clusters have to advance their own three-year plan for waste collection and removal and promotion of recycling in the periphery. It has been found that local authorities with lower socio-economic status tend to pay more for waste collection. The municipal clusters model is expected to lower waste expenditure costs substantially while at the same time increasing the efficiency of waste treatment services.
The support provided by the MoEP will be used for developing new waste infrastructure in the local authorities and for constructing municipal waste sorting and recycling facilities, treating construction and demolition waste, increasing enforcement, and streamlining efficient waste collection systems.

Hopefully, this new reality where one waste collection contractor services an entire region will finally be realized, making it possible to close the circle by making investment in materials recovery and recycling facilities economically feasible. And, of course, by supporting the regional municipal clusters, the MoEP will further advance its strategic waste treatment program.

6.2.5.2 ISRAEL CEMENT SECTOR AND THE WASTE CO-PROCESSING STATUS

There are 4 integrated cement plants in Israel with a production capacity of 7,7 Million tons of cement. The market had been dominated by Nesher company for several years but, two new producers have entered the country, although Nesher is still clearly the main producer with 80% of the capacity. In 2016 growth accelerated with domestic demand reaching 4,83 Million tons.

Group / Company	*Number of plants*	*Cement Production capacity (Million t)*
Nesher Israel Cement Enterprises Ltd	2	6,2
Israel Shipyards Ltd	1	1
Har Tuv Cement Ltd	1	0,50

TABLE 16. CEMENT PRODUCTION FACILITIES IN ISRAEL

Local waste management practices as well as environmental regulations present many barriers to the use of alternative fuels in the Israeli cement industry:

- Landfilling fees in Israel are not high enough (although they have increased substantially in the last decade). So, there is no financial incentive to divert from landfilling to more advanced waste treatment methods.
- The Ministry of Environment has the strategic goal of landfilling reduction and to design and implement legislation focus on this target, although they do not guarantee proper treatment or even any improvement in waste management.
- There is not any specific governmental financial support, for co-processing, despite the national-level environmental benefits of this initiative (already recognized by the ministry).
- In addition, several limitations in the permitting process inhibit the use of alternative fuels in Israel: not typically limited by fuel substitution rates (or feeding rates), as long as stack emissions limit values are being met, but also limitations at the waste flow (10t/h, maximum of 40% TSR, under negotiation).
- The conclusion of a report issued by Ecofys[7] states that “Local factors constrain the market potential to a much larger extent than the technical and economic feasibility of the cement industry itself”, referring to an excessive bureaucracy and poor waste management practices.

In 2016 a refuse derived fuel (RDF) plant at the Hiriya Recycling Park has been launched by a team of partners, including the Dan Municipal Sanitation Association, Nesher Israel Cement Enterprises and the **Veridis** environmental service corporation. It is a waste sorting and recycling plant that sits at the foot of the region's towering former garbage dump. The facility will be producing alternative fuel to **provide a source of energy for cement production** at the nearby Nesher plant.

[7] Status and prospects of co-processing of waste in EU cement plants. Case studies. May 2017

The RDF plant, **one of the most advanced and largest in the world**, will use about 1,500 tons of household waste per day, amounting to 0.5 Million tons of trash per year, according to the project.

"The RDF plant is an innovative, flexible and modular plant, which serves as successful model for a collaboration between industry that needs raw materials for energy and an urban sector that needs a solution to the waste problem and a technological body that is ready to take a risk despite the challenge," Doron Sapir, chairman of the Hiriya Recycling Park.

Using industrial and municipal waste as a combustion material, RDF has become recognized globally as an environmentally friendly fuel source commonly used to power the cement industry. The household waste is sorted using advanced technological methods, and those materials appropriate for burning, such as plastic bags, other plastics, textiles, tree trimmings, cardboard and paper.

According to an article by Amit Marmur, VP of environmental affairs at Nesher, issued in ZKG 1-2, 2018, Nesher Cement has made substantial progress with its alternative fuels program, reaching a fuel substitution level of 20 %, using several types of alternative fuels. Nesher plans on increasing the use of alternative fuels, with an interim goal of reaching 40 % by 2020, despite local constraints such as low landfilling fees and excessive bureaucracy.

- 2000: Nesher started using alternative fuels in the early 2000's, when a system for storing and feeding spent solvents (e.g., from the pharmaceutical industry) was built at the Ramla plant. For nearly a decade, the fuel substitution rate remained at a low 1-2%,
- 2003: an experiment for using **scrap tires** as an energy source at Har-Tuv plant (which is no longer owned by Nesher), was finally not approved by the Israeli Ministry of Environmental Protection due to public concerns and pressure.
- 2009: experiment for using **refuse derived fuel (RDF)** at Ramla plant. A permit limited to 10t/h and no more than 40% substitution rate was issued for one of the kilns.
- 2012: an agreement was signed between Nesher, the Dan Municipal Sanitation Association, and Veolia Israel (now known as Veridis), for building a RDF plant at the former Tel-Aviv region landfill (Hiriya), to be used by Nesher.
- 2013: Start point of the RDF plant and use of RDF from industrial sources in Nesher.
- 2014: the permit was expanded to the other kiln, but the limitations on the feeding rates remain. Conversations between Nesher and the Dan Municipal Sanitation Association (Tel-Aviv region) regarding the use of RDF to be produced from the municipal waste have also started (landfilling rates increased from 2.5 €/t in 2007 to 25 €/t in 2012.
- 2015: Nesher receives the "Industry in the Environment Award", for its accomplishments in the field of alternative fuels, and for providing a waste end-solution and environmental benefits at the national level.
- 2016: trials were conducted in the RDF plant.
- 2017: official launch of the RDF plant (500.000 t/a and expenses reaching more than 75 million Euros, funded by Nesher and its partners, with no governmental support). These quantities lead to approximately a 20 % fuel substitution rate (30 000 t of industrial RDF and more than 20.000 t/a of chopped scrap tires).

A state of-the-art storage and feeding system was built at the Nesher Ramla plant (1200 t capacity, it is kept at a low pressure to avoid odors and the filtrated air is directed to the kiln and combusted).

6.2.5.3 SUMMARY

The information concerning waste management and waste co-processing situation in Israel is summarized in the two following slides:

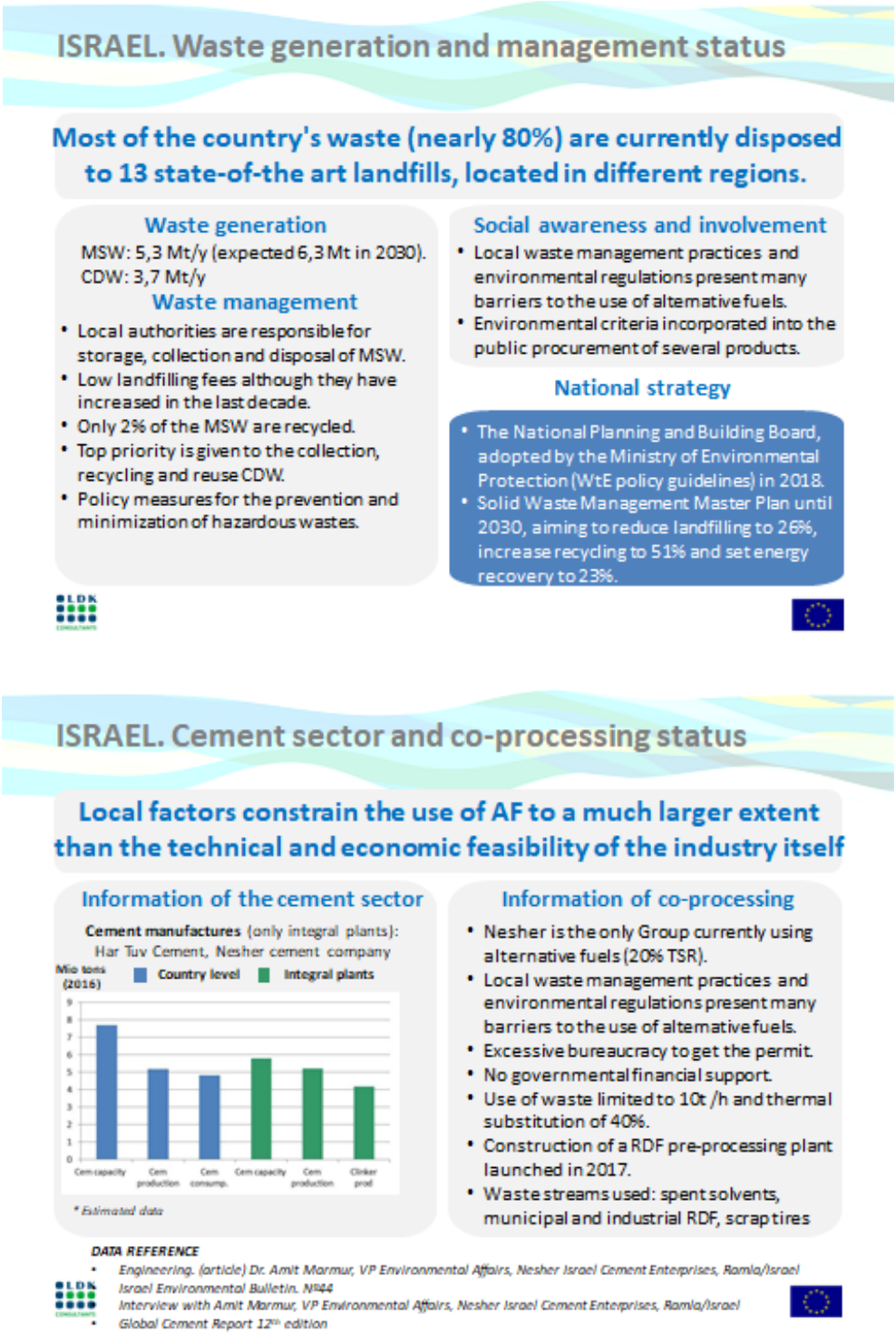


FIGURE 52. SUMMARY OF THE ISRAELI WASTE MANAGEMENT AND CO-PROCESSING SITUATION

6.2.6 JORDAN

6.2.6.1 WASTE GENERATION AND MANAGEMENT STATUS

Solid waste management is one of the target areas of the Government, together with water and waste water issues. The Ministry of the Environment has been designated as the responsible organism for developing a solid waste management policy and the corresponding laws and regulations and monitoring and enforcing compliance. Nevertheless, the growing population, insufficient financial resources, an inadequate management and poor technical skills have given rise to an important environmental challenge.

The main objectives in the Government National Agenda for Sustainable Development concerning waste management are:

- To extend waste service coverage by providing financial, technical and human resource capacity-building to empower concerned authorities
- To promote environmentally sound solid waste disposal and treatment
- To minimize generation of solid waste
- To maximize environmentally sound solid waste reuse and recycling.

The growing industrialization and high population growth rate have led to a MSW generation of approximately 2 million tons per year, being most of them disposed in unsanitary landfills and dumpsites, leading to public health risks, adverse environmental impacts as well as socio-economic problems. However, these wastes could be used to generate energy, improving the recycling rates, reducing at the same time the dependence on fossil fuels and, at the same time, reducing the amount of waste sent to landfills.

The Jordan's policy on waste management encourages private sector participation in infrastructure, trying to increase private sector investment in infrastructure, and attracting foreign technology and know-how.

6.2.6.1.1 TYPE OF WASTE PRODUCED IN THE COUNTRY

According to the GIZ- Sweepnet, ANGed report on the solid waste management situation in Jordan dated on April 2014, Jordan is generating an important volume of different types of wastes being Agricultural and household waste the most significant streams. A notable volume of CDW is also generated as well as certain quantities corresponding to another different kind of industrial and commercial wastes

•Municipal Solid Waste

Jordan generated, at the GIZ report time, about 2 million tons of MSW, 45,000 tons of hazardous industrial waste, and about 4,000 tons of medical waste, per year, being the generation per capita of household waste 0,9 kg per day in urban and 0.6 kg per day in rural areas. Currently, due to the population growth, the estimated municipal waste generated according to the last five years average production is around 3 million tons per year according to Ecomena.

The average MSW composition is: 40% is organic waste, 10 % are recyclable and 50% suitable for energy production as they have a high calorific value and energy potential capable to produce 340 kWh/ton waste. In general terms, MSW in Jordan is characterized by a high organic content, with combustible matter comprising more than 90% of the total waste.

- **Construction and demolition wastes**

Some 2,6 million cubic meters of CDW are annually produced, what represents more than 3 million tons per year. These wastes are normally landfilled or dumped although they could be used mainly for material recycling and partially for obtaining alternative fuels.

- **Agriculture Waste**

More than 4 million tons of agricultural waste is produced annually of which some 40,000 are olive mill solid waste that could be used as alternative fuel in the cement industry. In general, this huge volume of agricultural waste is not used and is normally dumped.

- **Sewage sludge**

1.83 million m^3 of septic and sewage sludge from treatment of 44 million cubic meter of sewage water is generated in Amman area, with the estimation of more than 85,000 tons of dry matter.

	Parameter	Unit	Value
1	Population	N^o	. 6,388,000
2	Municipal solid waste (MSW) generation	Ton/year	2,077,215
	Composition of MSW		
	Food waste	%	50
	Dry recyclables	%	34.5
	Paper and cardboard waste	%	15
	Glass	%	2
	Metals	%	1.5
	Plastics	%	16
	Others	%	15.5
3	MSW per capita generation:		
	urban	kg/capita/day	0.9
	rural	kg/capita/day	0.6
4	Estimated MSW general annual growth	%	3
5	Hazardous industrial waste generation	ton/year	45,000
6	Medical waste generation	ton/year	4,000
7	Agricultural waste generation	ton/year	>4 million
8	Packaging waste generation	ton/year	700.000
9	Construction and demolition waste generation (Amman)	m^3/year	2.6 million
10	Scrap tires generation	No./year	2.5 million
11	Waste oil generation	ton/year	10,000-15,000
12	E-waste generation	Piece./year	30,000

TABLE 17. KEY FACTS AND FIGURES ON SOLID WASTE MANAGEMENT IN JORDAN FOR THE YEAR 2012. SOURCE: GIZ REPORT

- **Hazardous waste**

There are no accurate records for the quantity and quality of industrial HW, although several studies have been conducted to address the subject. Nevertheless, it's been estimated that 45,000 ton/year were generated in 2012 throughout the country, including about 10-15,000 tons of waste oils.

6.2.6.1.2 WASTE COLLECTION AND TREATMENT

MSW collection coverage is estimated at about 90% and 70% for urban and rural areas, respectively. According to the GIZ report 2014, most of the MSW ends up at dumpsites (45%) and landfills (48%), whereas only 7% are recovered. Although the solid waste management is mainly undertaken through the public sector it has significantly improved since 2005 and there can be opportunities for the private sector; which is not a significant player in this field yet. Landfilling in Jordan often means dumping the waste in cells with levelling by trash compactors to reduce the size and the thickness of the layers, and finally cover the waste with soil. Landfills in Jordan are operated by CSCs (which usually serve more than municipality) with dual supervision of the Environment and Municipalities Ministry.

Amman accounts for almost half of the total solid waste generated in Jordan, which are collected, transported and disposed to the Al Ghabawi landfill by the municipalities.

In the whole country there are 21 working landfill sites, out of which 7 are closed. Landfills in Jordan have been located following the criteria of the amount of population in the area instead of environmental criteria, except for Al Ghabawi landfill, which is the first one constructed in Jordan with gas collection systems and financial assistance from the World Bank, receiving 50% of the waste generated in Jordan. It has been the first municipal carbon finance partnership in the Middle East. The electricity generated from landfill gas will be delivered to the national grid, displacing electricity produced by grid connected power plants that traditionally use heavy fuel oil.

There is no specific legal framework or national strategy for solid waste management at the moment, as Municipalities do not have enough funds to setup modern waste collection infrastructure, recycling facilities, waste disposal systems and waste to energy plants. The Ministry of Environment and Ministry of Health have no clear responsibilities in enforcing environmental and health standards. Recycling is very limited in Jordan and undertaken by the informal sector; this means many of the materials are recycled inside landfills, and they do not follow any regulation or legislation.

The private sector companies are active in the sorting of waste in landfills (iron and aluminium, plastic, paper, cardboard and glass bottles). Most of the work done inside the landfill is done through scavengers employed by the private sector. According to the study performed by HRMars in November 2014, most of the landfills in Jordan are rented for private sector companies and waste recycling depends mainly on the prices of the sorted materials.

The role of private sector in solid waste management is also limited, except some pilot projects, such as the one initiated ty the government in 2009, with the objective to strength the operational, financial, and environmental performance of municipal solid waste management and to build two waste transfer stations in the northern and western areas of Amman.

Waste-to-energy technologies offer a very big potential as renewable energy sources and to mitigate climate change. However, these technologies imply many challenges to the country and population. Currently, the waste sector is administrated by the government. Poor regulation and insufficient financial resources are limiting the available options to adapt these technologies. Private investments and collaboration with the private sector are the key solution in this issue.

6.2.6.1.3 PUBLIC AWARENESS

Financial restrictions, with no availability of adequate and proper equipment, and limited trained and skilled manpower have contributed so much to the poor solid waste management programs in Jordan.

In the communities there is a low level of awareness and education concerning the health and environmental impacts of the incorrect solid waste management, and therefore it makes difficult to implement recycling and disposal programs that require the cooperation of these communities.

The Public Action for Water, Energy and Environment funded a five year program in 2009 where one of the objectives was to improve solid waste management, through the development of communication strategies and campaigns in media (radio, lectures, brochures, contests, etc.).

A national training programme on integrated suitable waste management was also conducted with H2020 funds, in September 2012.

6.2.6.2 JORDAN CEMENT SECTOR AND THE WASTE CO-PROCESSING STATUS

The country's construction sector has become key to both job creation and economic growth. Cement consumption in 2016 has been around 4,4 Million tons, and from these, almost 77% have been destined for the housing sector.

Jordan has 5 integral cement plants and one grinding plant, having a total installed capacity of 10,45 Million tons cement and 8,5 Million tons of clinker. The overcapacity remains being a problem, even more with the construction of a new cement plant in Palestine, which constitutes all exports from Jordan, and very high energy costs.

The largest producer is LafargeHolcim who operates two plants with a total nominal cement capacity of 4,8 Million tons, although the useable capacity lied between 3,9-4 Million tons in 2016 due to the high production costs. The company is followed by Al-Rajhi Cement with a single kiln line of 1,8 Million tons. Then comes Qatrana cement, a subsidiary of Saudi Arabian Cement Company with a 1,65 Million tons integrated plant and the fourth one is Manseer Cement and Mining Co who has an integrated plant of 1,2 Million tons cement.

The grinding plant located in Muweqqar has a production capacity of 1Million tons cement per year.

Group / Company	*Number of plants*	*Cement Production capacity (Million t)*
Arabian Qatrana Cement Company	1	1,65
Al- Rajhi Cement	1	1,80
Northern Cement Co. (Jordan)	1	1,0
LafargeHolcim Ltd	2	4,80
Manasser Group	1	1,20

TABLE 18. CEMENT PRODUCTION FACILITIES IN JORDAN

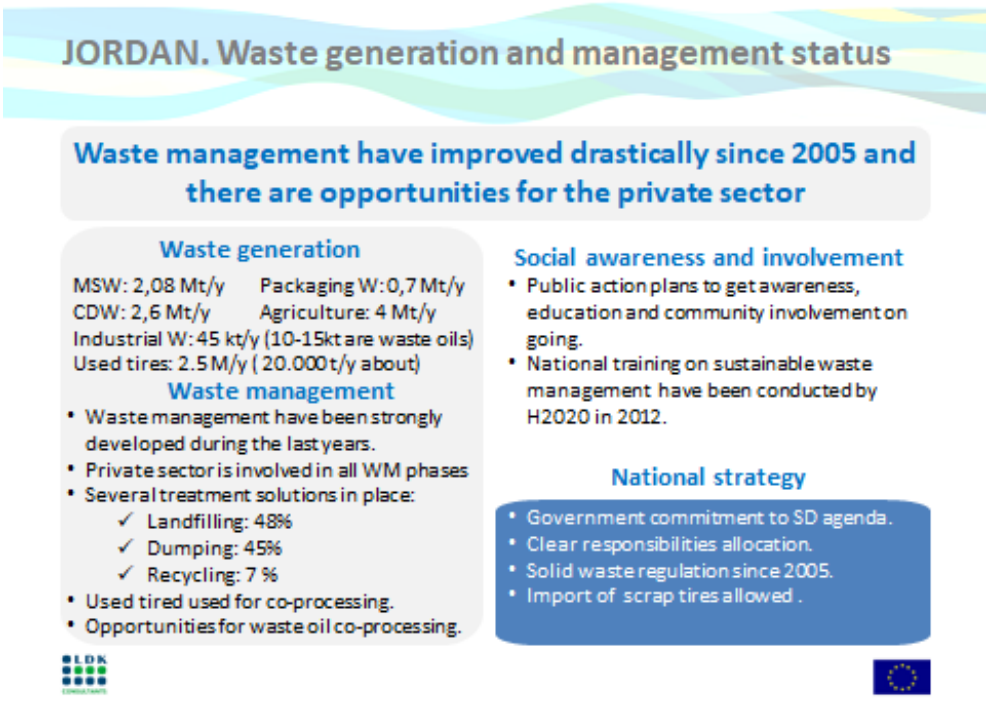
No alternative fuels were being used in Jordan at the end of 2016 while heavy fuel oil was dominating the kilns with almost 80% utilization.

Clinker production at Fushais plant has been suspended in 2013 due to the high energy costs and to not being permitted the use of alternative energy resources to compete with other companies.

Jordan imported more than 95% its energy needs in 2016 and was aiming to diversify the use of renewable energy from 3-4% to almost 20% by 2020 with investments in wind farms and solar power projects. Waste co-processing would clearly help to reach these objectives, reducing external energy needs for the operating cement plants.

6.2.6.3 SUMMARY

The information concerning waste management and waste co-processing situation in Jordan is summarized in the two following slides:



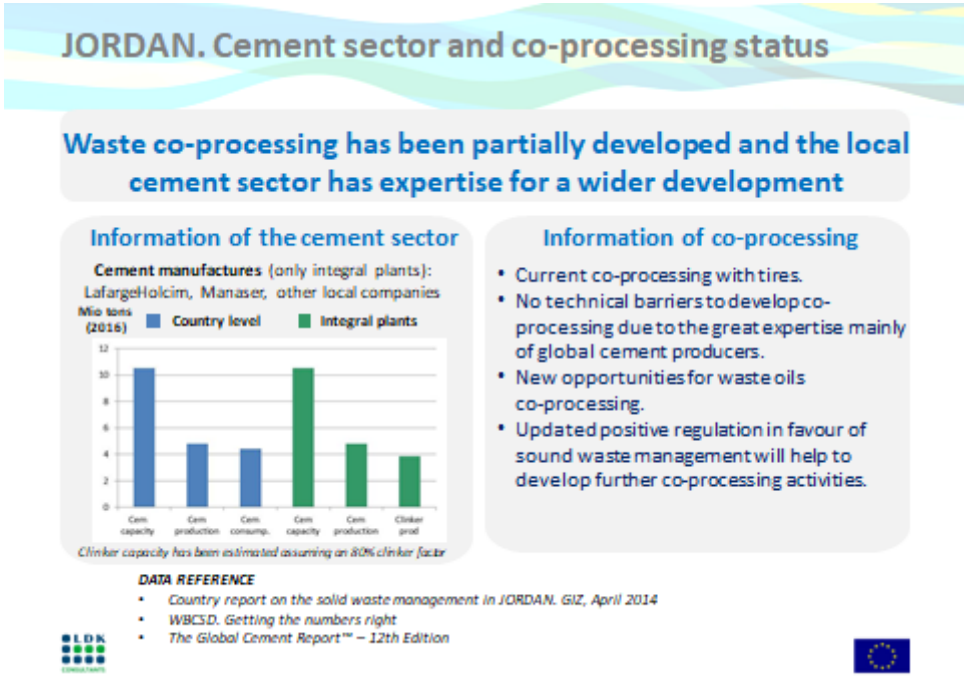


FIGURE 53. SUMMARY OF THE JORDANIAN WASTE MANAGEMENT AND CO-PROCESSING SITUATION

6.2.7 LEBANON

6.2.7.1 WASTE MANAGEMENT SITUATION

Environmental laws and regulations concerning solid waste management are outdated and are not empowered by the Government, even when Lebanon has joined the conventions of Barcelona (1976), Basel (1994) or Stockholm (2001). Municipalities are responsible for waste collection and disposal, but they have strongly relied on foreign aid led by the Council for Development and Reconstruction and Office of the Ministry of State for Administrative Reform.

In July 2015, a solid waste crisis erupted in Lebanon after the closure of the country's main landfill in Naameh, with the stop of the collection service. The crisis lasted eight months, during which the population had to cope with mountains of waste. NGOs, private companies and the civil society triggered different initiatives to deal with MSW.

In March 2016, the Government eventually announced a 4 years plan to phase out of the emergency state, relying on the construction of 3 coastal landfills which shall receive the MSW of half the country's population living in the dense and urbanised BML region.

Meanwhile the plan had three immediate actions:

1) Reopen de Naameh landfill for two months, in order to get rid of the accumulated waste generated during the crisis.
2) Continue the research of possible waste to energy solutions
3) Reaffirm the possibility for municipalities to create their own way of managing waste.

The plan also sets decentralisation of waste management and waste-to-energy technologies as the basis of the future strategy. However, no practical decisions, incentives nor guidelines have been

approved and solid waste management remains one of the country's most urgent challenges alongside with other public utilities such as energy, water supply and sanitation.

6.2.7.1.1 TYPE OF WASTE PRODUCED IN THE COUNTRY

- **Municipal solid waste (MSW)**

According to the GIZ-SweepNet- report (2014) on SWM in Lebanon, the average MSW generation per capita is of 1,05 kg/day, with variation between rural areas (0,8 kg/day) and urban areas (0,95 – 1,2 kg/day), being the total generation in the country estimated to 5600 tons/day.

MSW generation projection according to the GFA Report issued in September 2017, for the following years is:

- 2.26 million t in 2015
- 2.44 million t in 2020
- 2.66 million t in 2030

6.2.7.1.2 WASTE COLLECTION AND TREATMENT

The waste is disposed in open-containers placed at specific locations on the road. Street sweeping is either manual or mechanised and wastes are collected by compacting trucks and transferred to two sorting centres: Qarantina (2,000 tons/day, 5 sorting lines) and Amroussieh (1,000 tons/day, 4 sorting lines), where there is a first manual sorting and then a mechanical one with magnetic separation and rotating sieves. (Sukleen, 2015; CDR, 2015).

- Part of the organic fraction, from the Qarantina (200 tons/day) and Amrousieh plant (100 tons/day), is transferred to Coral composting plant (300 tons/day) to produce low quality compost, which is sold or given to farmers or landfilled.
- Recyclable fraction is sold to industrials, at prices fixed by contract (StREG, 2016).
- The residual fraction, still containing a large amount of organics, is baled and sent to Naameh landfill.
- Bulky items and inert materials are sent to the Bsalim landfill.

6.2.7.1.3 PUBLIC AWARENESS

Stakeholders of the Lebanese waste sector range from political and religious leaders to other institutions and all sizes of waste recyclers, with a clear lack of cooperation between them.

Sukleen implemented a voluntary basis new recycling programs with the following activities:

a) Ther Red&Blue campaign for sorting at source glass / plastic / metal and paper / cardboard, will bring stations and partnerships with institutions, schools or buildings.
b) Implementation of reverse vending machines in supermarkets for recycling of plastic bottles (Sukleen, 2015), with dedicated trucks to collect these recyclables.

The impact of these measures was however limited to some areas and tends to not be much recognised by the majority, above all concerning the fate of organic waste, which is not considered a significant resource. Awareness events about composting have been carried out in museums, universities or schools.

Many actors have started to recycle waste, operating at the margin of the central system. They process between 100 and 500 tons per day, including not only MSW, but also other waste such as scrap metals. On the other hand, there are also recycling programs organized by different NGO's working with different sort of waste: paper, hospital waste, etc.

However, Government and population are each time more aware about the waste management problem and, in April 2019, there will be a waste management exhibition to exchange ideas and information about potential solutions and new technologies (http://www.wastemgmtexpo.com/index.php).

6.2.7.2 LEBANON CEMENT SECTOR AND THE WASTE CO-PROCESSING STATUS

Lebanon has three cement producers with almost 7 Million tons capacity. Cimenterie Nationale had the highest market share in 2016 (43% with Chekka plant). Then comes LafargeHolcim, with a 38% market share, operating a 2,5 Million tons cement plant. The company also manufactures white cement through its subsidiary Société Libanaise des Ciments Blancs. The third one is Ciment de Sibline, with a 1,3 Million tons cement plant located in Mount Lebanon, belonging to Secil Group.

The export market fell dramatically in 2014 due to the strong competition of Greece, Turkey and Iran exporting their surplus volumes at highly competitive prices throughout the Mediterranean. Lebanon exports moved mainly to Syria and Jordan, but the political situation made it no longer possible so, trade was declined.

There has been a significant fall in the number of new construction permits and other infrastructure projects in 2015. Despite the situation, LafargeHolcim has undertaken important investments to reduce dust emissions or to improve operational efficiency and reduce energy consumption.

Group / Company	*Number of plants*	*Cement Production capacity (Million t)*
Cimenterie Nationale	1	3.0
LafargeHolcim Ltd.	3	2.5
Secil S.A. (Group)	1	1.3

TABLE 19. CEMENT PRODUCTION FACILITIES IN LEBANON

There are no technical reasons to delay waste co-processing development in the local cement industry in Lebanon. Both of the international groups operating in the country have wide expertise on the matter. Main barriers lack of administration support and social awareness. A close collaboration between authorities and the local cement sector could contribute to solve a part of the MSW present crisis. Social awareness should be also necessary to prevent rejection to co-processing.

6.2.7.3 SUMMARY

The information concerning waste management and waste co-processing situation in Lebanon is summarized in the two following slides:

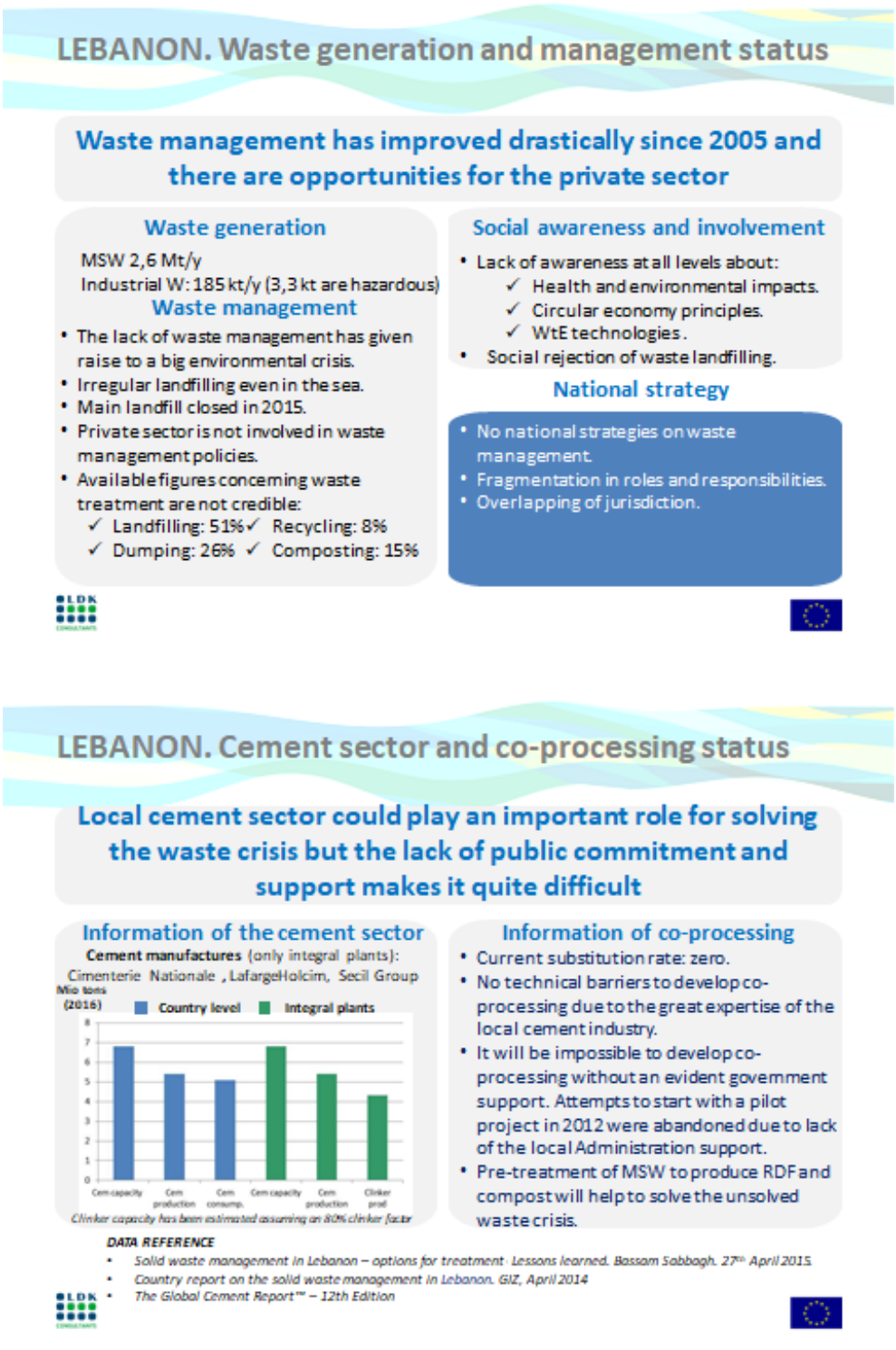


FIGURE 54. SUMMARY OF THE LEBANESE WASTE MANAGEMENT AND CO-PROCESSING SITUATION

6.2.8 MAURITANIA

6.2.8.1 WASTE GENERATION AND MANAGEMENT STATUS

The sustainable development national strategy has been developed in 2006, involving, among other areas, the institutional and political means for an efficient management of the environment, the sustainable access to basic services and an integrated and participatory management for efficient use of natural resources.

6.2.8.1.1 TYPE OF WASTE PRODUCED IN THE COUNTRY

- **Household waste**: some 0.5 million tons are estimated.
- **Medical waste**: they are a big problem in the country, as they are assimilated to household waste, being discharged into bins, landfills or dumps.
- **Construction and demolition waste**: municipalities are not responsible for these wastes, being the producer in charge of their management.
- **Other waste** (industrial and agricultural). They are similar to household waste. No provision has been made to organize this sector.

6.2.8.1.2 WASTE COLLECTION AND TREATMENT

The private sector is involved in waste collection in the city of Nouakchott through and internal operator, contracted by the Agency of Urban Development. This contract covers collection and disposal of household waste from the city to the landfill site. Wastes produced in the city have been 148.494.497, 184.508.745 and 211.758.464 tons in 2010, 2011 and 2014 respectfully.

Waste management in the rest of the cities is a municipal responsibility, although they do not have enough financial or human resources to deal with this issue.

The study by the GIZ-Sweepnet on solid waste management in Mauritania, showed that the average of the households produced everyday was 0,5 kg per capita in urban areas and 0,3 in rural ones.

Recycling rate is too low. In April 2016 Gret and Hydroconseil have carried out a study on the recycling companies in the city of Nouakchott, financed by the World Bank with the objective to integrate waste pre-treatment installations into the waste management policies, starting with seven recyclable wastes: plastics, scrap, aluminium, metals, waste tires, and recipients.

There is not any specific taxation for waste management in Mauritania. In fact, a similar tax on the water bill was quickly abandoned.

6.2.8.1.3 PUBLIC AWARENESS

Waste management is not very present in urban strategies in Mauritania so it is not taken into account at all in the master plan for urban development, for instance, neither in the city of Nouakchott, nor in other secondary ones which are facing the same problem.

The Ministry of Environment has organized a national campaign prohibiting the import, marketing and use of plastic packages in 2012. Several NGO's have also promoted these population awareness initiatives, such as the "Acteurs locaux de l'assainissement: innovations au Sénegal et en Mauritanie». Different activities to involve neighbours have been organised in the launching day of the initiative.

A training plan for stakeholders involved in waste management activities, including mayors and councillors, municipalities, operators and opinion leaders has also been proposed.

6.2.8.2 MAURITANIAN CEMENT SECTOR AND THE WASTE CO-PROCESSING STATUS.

No clinker is produced within the country, being mainly imported from Turkey, Lebanon and Spain. However, there are some grinding plants. So there is no chance for co-processing so far.

Group / Company	*Number of plants*	*Cement Production capacity (Million t)*
ASML Mauritania / Ciments du Mauritaine	1	1,33
Ciments du Maroc / Cinord	1	0,2
Heidelberg Group / MACFI	1	
Vicat Group / BSA Ciment Mauritania	1	0,45

TABLE 20. CEMENT PRODUCTION FACILITIES IN MAURITANIA

6.2.8.3 SUMMARY

The information concerning waste management situation in Mauritania is summarized in the following slide:

FIGURE 55. SUMMARY OF THE MAURITANIAN WASTE MANAGEMENT AND CO-PROCESSING SITUATION

6.2.9 MONTENEGRO

6.2.9.1 WASTE GENERATION AND MANAGEMENT STATUS

According to the EC, waste management in Montenegro is one of the priority issues in the country, as the waste management system is still very poor. Cooperation between state and local authorities needs to be strengthened, new investments are needed, with special focus on waste separation and recycling.

There are no reliable figures on waste generation as not all municipalities have and exact record on how much waste is produced in their municipality. According to extrapolation of official data, there would be about 160.000 tons produced per year so about 250 kg per person per year (data: 2017), but official data do not always include waste dumped illegally.

6.2.9.1.1 TYPE OF WASTE PRODUCED IN THE COUNTRY

- **Municipal solid waste**

The amount of municipal solid waste generated in 2013 has been almost 0,3 Million tons. Households and commercial waste generation is similar throughout the country. However, waste generated by the tourism is mainly concentrated in the coast during summer time. This situation should be taken into account when management installations are being built.

The National Waste Management Plan includes projections of municipal waste generation in the future in 4 different regions, assuming changes in the population based on projections of the Statistical Office of Montenegro. The global projection shows an average compound rate of growth of 1,7% per year (eunomia and LDK consultants report, Jan 2017).

- **Construction and Demolition waste**

The Report on the implementation of the National Waste Management Plan in 2013, says that CDW is around 90.000 tons, although the source is not reliable.

- **Waste tires**

According to the Waste Management National plant 2014-2020, a concession is required to carry out the management of waste tires. The volume of waste tires which should be taken to the municipal enterprises or regional landfills by the distributors is around 3.600 tons per year.

- **Industrial waste**

According to MONSTAT (Department of Forestry and Environment) Statistics 2014, there is a very large increase in hazardous waste generation in the mining sector, up to 300.000 tons, which has not been justified.

Very big quantities of old industrial wastes stored in the country are becoming a major problem, due to the exposure to contaminated dust particles and the risk to contaminate surface and groundwater.

These are red muds produced in the aluminium industry, marl waste and tailings (inert residues) from the mining industry and other toxic flotation tailings from zinc and lead industry.

6.2.9.1.2 WASTE COLLECTION AND TREATMENT

Around 70% of total waste collected, end up in any of the 155 medium to large unregulated landfills across the country. National targets of waste collection for 2017 were between 65% and 95% depending on municipalities.

Waste recycling hardly exists, was less than 3% of waste is recycled in Montenegro in 2015. The goal set up in the National Plan for 2020 is 50%, which is too optimistic as the waste recycling target set by the municipalities in 2017 has been something between 0.8% and 8%.

However, the National Waste Management Plan has set ambitious recycling, recovery or reuse objectives for 2020:

- 50% of municipal waste.
- 20% of plastic waste.
- 70% of the collected CDW.
- 85% (recycled or reused) and 95% (recovery) of end of life vehicles.

The Plan also sets a target for organic biodegradable municipal waste landfilling, assuming that these wastes must not be more than 50% of the total mass of biodegradable municipal waste produced in 2010 by 2020, and no more than 35% by 2025.

Waste management infrastructure is not developed either. It is another target of the National Solid Waste Management Plan. There are currently 9 recycling plants, 4 material sorting facilities, and 2 sanitary landfills with new structures under discussion.

6.2.9.1.3 PUBLIC AWARENESS

There will be two different branches concerning awareness. On one side, activities will focus on raising public awareness in general and, on the other side, increasing the self-awareness of the individuals.

The project "Preparation and Implementation of the National and Local Waste Management Plans in Montenegro", implemented by the Ministry of Sustainable Development and Tourism, is carrying out different activities and public campaigns directed to improve waste governance, as a continuation of other ones already conducted in this area. The good coordination and communication between the stakeholders at local, regional and national level is the key of their success.

6.2.9.2 MONTENEGRO CEMENT SECTOR AND THE WASTE CO-PROCESSING STATUS.

Montenegro does not have any clinker production plant and imports all the required cement from Albania, Croatia, Greece and Serbia to meet cement demand. Cement consumption in Montenegro was around 633 kg per capita.

6.2.9.3 SUMMARY

The information concerning waste management situation in Montenegro is summarized in the following slide:

FIGURE 56. SUMMARY OF THE MONTENEGRO WASTE MANAGEMENT SITUATION

6.2.10 MOROCCO

6.2.10.1 WASTE GENERATION AND MANAGEMENT STATUS

Solid waste management is one of the major environmental problems in Morocco. Generation in the country goes up to 7 Million tons with an annual waste generation growth rate of almost 3%. There is a clear lack of proper infrastructures and suitable funding to carry out waste disposal in areas outside of major cities. According to the World Bank, in 2008 “only 70 percent of urban MSW was collected and less than 10 percent of collected waste was being disposed of in an acceptable manner”.

6.2.10.1.1 TYPE OF WASTE PRODUCED IN THE COUNTRY

- **Solid waste**

According to the 2014 GIZ-Sweep-net report on waste management in Morocco, the overall solid waste generation in Morocco was almost 6.852 Million tons in 2013. Urban waste generation is now approximately 0.76 kilos per day per capita, whereas rural waste generation per capita is about 0.3 kilos per day.

- **Industrial waste**

The socio-economic development and population growth that Morocco has experienced in recent decades have led to an increase in the quantity and complexity of the quality of special waste produced by the industrial sector. In 2013, the Moroccan industrial sector produced about 1.6 million tons of solid waste, of which 289.385 MT is hazardous waste.

- **Construction and demolition waste**

More than 7 million tons of these wastes are produced in the country annually. CDW is generally excluded from the household waste management services. They are taken to landfills, where they are deposited separately and will be used afterwards to cover waste or for the construction of tertiary access roads.

- **Agricultural waste**

There are no reliable figures about the generation or relevant quantities of this waste. Although the agricultural waste by-products have a great potential in Morocco, they have never been studied in detail, and their management is not well developed at all, some private companies and non-profit organizations are trying to start up with this industry.

6.2.10.1.2 WASTE COLLECTION AND TREATMENT

Urban solid waste collection is regular and almost daily for an estimated 5.5 million metric tons per year. 37% of the total waste generated is disposed of in controlled landfills. Concerning industrial waste only 8% of them is collected and around other 8% of these is disposed without prior treatment.

To cope with the challenges posed by the management of household and similar waste, the Ministries of Interior, Finance, and Environment jointly developed a National Solid Waste Program (PNDM), which aims to upgrade the management of municipal solid waste by 2022. The World Bank provided both financial and technical support for this program under Development Policy Loans (DPLs).The objectives of the program were revised in 2012 to:

- Ensure the collection and cleaning of household waste to achieve a collection rate of 85% in 2016, 90% in 2020 and 100% in 2030.
- Ensure access to controlled landfills for household and similar waste for all urban centres (100%) by 2020.
- Rehabilitate or close all existing disposal sites (100%) by 2020.
- Modernize the waste sector by increasing professionalism.
- Develop the sorting-recycling-recovery chain, with pilot sorting projects, to reach a recycling rate of 20% by 2020.
- Expand and implement solid waste master management plans for household and similar waste for all prefectures and provinces in the Kingdom.
- Train and raise awareness among all stakeholders.

Municipalities are responsible for municipal waste management, while the industrial sector is responsible for the management of their produced waste. However, there is hardly an appropriate collection, treatment and disposal infrastructure and nearly all hazardous waste produced by the industrial sector is disposed of in uncontrolled dumps, municipal landfills, on nearby land, in abandoned quarries or along rivers, without any treatment or control. This process is quite often subcontracted to informal operators, who sort the waste that has resale value and dispose of the rest of the waste considered hazardous. This informal system has resulted in serious consequences for public health, the environment and the future socio-economic activities in the country.

The Government encourages the private sector to take part in waste management but, as there are recurrent problems with them as, for example, there are no clear terms of reference, bids are made with very low prices, payment deadlines are not respected by the municipalities, etc. Due to these issues, many contactors have broken their relations with the Government.

6.2.10.1.3 PUBLIC AWARENESS

As part of the support measures for the success of the National Municipal Waste Program (PNDM), an outreach and communication plan has been established. It consists of a campaign on the media (TV, radio and video spots); developing communication tools; a website that will be affiliated with the Department of Environment; and regional training workshops.

The Development Policy Loan granted in 2013, provides a new public participation tool in Morocco: citizen report cards that will enable the public to provide feedback on their city's solid waste services. The DPL also aims to increase transparency via public information access to policy information and disclosure of contracts with private companies.

6.2.10.2 MOROCCO CEMENT SECTOR AND THE WASTE CO-PROCESSING STATUS

Morocco has a total of 17 cement plants (12 integral facilities and 5 grinding units). LafargeHolcim signed an agreement with Société Nationale d'Investissement, having a combined capacity of 13,5 Million tons cement per year, with 6 integral plants and 3 grinding units. Italcementi, now part of Heidelberg group operates in Morocco through its subsidiary Ciments du Maroc with a cement production capacity of 5,3 Million tons. Other producers are Votorantim and Ciment de l'Atlas.

The economic and financial crisis hit the country much deeper and longer than expected, however two new subsidiaries entered the market: Atlantic Ciment and CIMSUD.

Moroccan cement producers have been shipping increasing volumes to foreign customers with almost 2 million tons cement exports. Concerning imports, Morocco has not imported any clinker since 2013.

Group / Company	*Number of plants*	*Cement Production capacity (Million t)*
Grouppe Adoha	2	3,2
Italcementi Group (Heidelberg)	5	5,3
LafargeHolcim Ltd	10	13,55
Votorantim Cimentos Group	1	1,9

TABLE 21. CEMENT PRODUCTION FACILITIES IN MOROCCO

Waste co-processing in the country is well developed, with a thermal substitution rate of 12%, reaching 20% in some plants, which will be increased thanks to RDF production.

An MSW pre-processing platform will be launched by **Geocycle Morocco**, expecting to play a significant role in professionalising the Municipal Solid Waste management in the country. It will be located near the Rabat landfill, contributing also to the circular economy of the country.

It has a capacity up to 90,000 tons of MSW per year and will not just increase the lifetime of Oum Azza landfill, but also create local jobs, offering an alternative source of livelihood to the community.

This model could be duplicated in other municipalities in order to help the environmental authorities to achieve their target of 20% of recovery of MSW by 2020.[8]

Ciments du Maroc, a company of Heidelberg Cement Group, has also signed an agreement with several Authorities on the 28th January 2018 in Agadir to invest near 100 Million DH in the construction of a conditioning plant for Solid Waste in this region.

The platform, which capacity is 150.000 tons, constitutes a significant contribution to the Solid Waste Management National plan, producing an AF for the cement plant, achieving the substitution of 35.000 tons of traditional fuels.

The plant is part of the Sustainable Development national plan, which aims to reduce fossil fuel import and consumption as well as the environmental impacts coming from waste disposal activities and the reduction of the GHG emissions. Agadir platform will become an ecological solution for solid, agriculture and plastic wastes in the region. Ciments du Maroc, with enough installations to co-process 100.000 tons waste/year will bring its strong expertise in waste co-processing, to this project.

Votorantim is immersed in the permitting process for AF co-processing in Temara plant and is developing an action plan aiming to develop notably co-processing along the next years.

6.2.10.3 SUMMARY

The information concerning waste management and waste co-processing situation in Morocco is summarized in the two following slides:

8 https://www.geocycle.com/first-municipal-solid-waste-pre-processing-platform-morocco

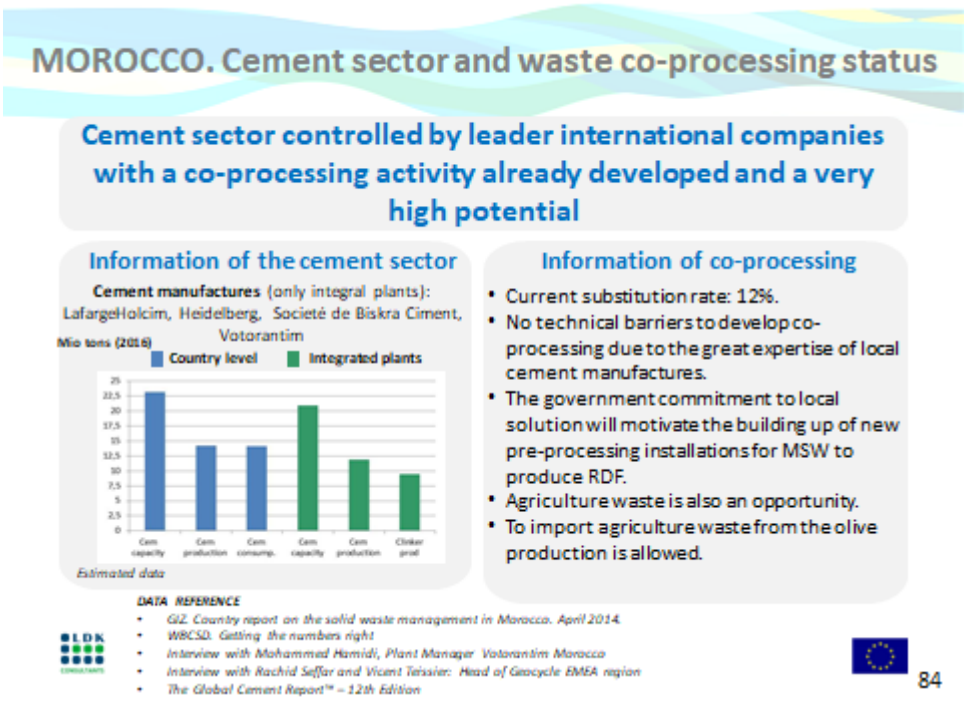


FIGURE 57. SUMMARY OF THE MOROCCAN WASTE MANAGEMENT AND CO-PROCESSING SITUATION

6.2.11 PALESTINE

6.2.11.1 WASTE GENERATION AND MANAGEMENT STATUS

Environmentally sound waste management is one of the most important issues concerning environment. Unfortunately, SW management had never been considered so important in Palestine. Nevertheless, new advanced infrastructures to improve this field are being built.

The "National Strategy for Solid Waste Management in Palestine 2010-2014" (NSSWM), is the first strategy for solid waste (SW) in the Palestinian Territory, and it constitutes the framework for everything related to develop the SW sector in the country. This strategy aims to set more efficient SWM systems, to improve the legislative, organizational, technical and economic framework and to reduce the negative impacts of SW on health and environment.

6.2.11.1.1 TYPE OF WASTE PRODUCED IN THE COUNTRY

There are very little available data about waste production in Palestine. According to 2014 GIZ-Sweep-net report on waste management in this territory, organic waste forms 59% of the waste, recyclables (paper, cardboard, plastic, glass and metal) form 29.4%.

- **Solid waste**

There are not reliable figures about waste generation in Palestine. It has been estimated at 1.387 million tons in 2012. Generation rate per capita ranges between 0.5 kg/day and 2.05 kg/day, depending on the country area (rural, urban or middle-size towns) and is expected to increase.

- **CDW**

There is not any available figure of the volume of construction and demolition waste produced in the country. They are disposed by the contractors in places assigned by the municipalities or, in case there is not any assigned place they are directly dumped, as they are not accepted in sanitary landfills.

- **Waste tires**

There is no treatment for this waste in Palestine; in fact, to recover the metal from tires, the informal sector burns them, causing significant environmental and health impacts. 5.500 tons have been produced in 2012, being some of them used for stabilization or protection issues and others are simply stored.

- **Agricultural waste**

Agricultural waste is included in the definition of solid wastes so all laws related to solid waste apply as well as to agriculture waste in Palestine. There is not a single strategy for this waste so, they follow the national solid waste management strategy. They are mainly used for composting, although these initiatives had not been successful.

- **Industrial / hazardous waste**

According to the referred GIZ report, almost 65% of waste generated comes from industrial establishments, although there is not exact data about the volume of hazardous waste produced.

6.2.11.1.2 WASTE COLLECTION AND TREATMENT

Solid waste collection is conducted mainly by municipalities or joint service Councils. The private sector is hardly involved in solid waste collection, being mainly active in recycling of special streams, such as CDW in Gaza strip, and recycling of some wastes such as e-waste and plastic, but to a very low rate. There have been two attempts for composting in municipal waste, but they failed due to lack of market for compost. The private sector also participates in waste transport in some areas.

According to a study conducted by Arlj, only 33% of solid waste are disposed in sanitary landfills, while the rest is disposed of in random dumpsites and/or burned. There are 163 open/random disposal sites in Palestine, of which more than half are not in use, but they have not been rehabilitated yet.

However, Palestine is each time more conscious about the importance of SW management issue and has invested a lot of money in adequate landfills and closure of dumpsites. Al-Minya landfill has been taken as a reference for other Mediterranean countries, such as Turkey, Lebanon or Jordan, in disposing of household garbage. An old landfill has been rehabilitated, funded by the World Bank Group and is operated as a Public Private Partnership, with sanitary and modern transfer installations, where wastes are disposed safely. It is also equipped with the necessary installations to carry out gas recovery and electricity generation, creating a sustainable system for managing solid waste.

Import of hazardous waste is prohibited in Palestine. Several initiatives had been launched but due to the lack of funding they have not been implemented, even when some of them have already been drafted, such as the publication of a list of categories of hazardous waste, the implementation of a documentary and traceability system or the preparation of a plan for hazardous waste management.

Almost 95% the industrial waste generated is mixed with municipal waste either at the collection stage or at the disposal stage, as most of the industrial establishments do not select them before, 7.3% collects their waste in separate containers, and 5.9% send their waste to the nearest dumpsite, but the separation does not mean that the waste is being recycled or sold or disposed of in a special manner.

6.2.11.1.3 PUBLIC AWARENESS

A National strategy 2013-2020 regarding the community participation and awareness has been developed, with three main objectives:

- To increase environmental awareness through effective environmental media.
- To integrate environmental aspects in Educational curricula and activities.
- To practice good Environmental values by all segments of the community.

This will be reached thanks to different actions such as the implementation of joint projects with civil society institutes to familiarize the informal sector with the technical and environmental and health aspects, or the satisfaction surveys carried out to the citizenship concerning municipal services' role in MSW management.

Media has also started to consider the environment and the solid waste in the news, reports, newspaper and so on.

6.2.11.2 PALESTINE CEMENT SECTOR AND THE WASTE CO-PROCESSING STATUS

Cement consumed in Palestine, more than 2.2 Million tons, is mainly imported from Israel (up to 90%), being the key trading partner but also from Egypt, Jordan, Turkey and Greece.

There are no cement plants operating in Palestine, at the moment. At the end of 2016, Palestinian Investment Fund subsidiary, Sanad Construction Resources Co, began work on Phase I of its Palestine Cement Factory, which included the construction of a 1 million tons cement mill at the southeast of Bethlehem, starting only with a grinding installation without clinker production.

As there is no local clinker production so far in Palestine there is no chance for waste co-processing, so far. The only possibility at present is to improve the MSW management while an integrated cement plant is, eventually, built up. In case local waste management is organized, some waste streams could be exported to nearby countries for co-processing, assuming it is allowed by those countries' regulations.

6.2.11.3 SUMMARY

The information concerning waste management situation in Palestine is summarized in the following slide:

FIGURE 58. SUMMARY OF THE PALESTINIAN WASTE MANAGEMENT SITUATION

6.2.12 TUNISIA

6.2.12.1 WASTE GENERATION AND MANAGEMENT STATUS

Solid waste management is a big challenge for Tunisia, where more than 2.5 million tons of garbage is produced each year. Tunisia waste generation amounts to 0.8 kg per day in urban areas, which is experiencing an average increase in waste volume by 3%. Biodegradable organic fraction constitutes around 68% of the MSW stream.

6.2.12.1.1 TYPE OF WASTE PRODUCED IN THE COUNTRY

- **Municipal solid waste**

The MSW generation in Tunisia accounted for 2,423 million tons in 2012 (GIZ) with a generation rate of 0.815 kg/d in urban areas and 0.150 kg/d in rural ones, according to a 2014 report by GIZ-Sweep-net on waste management in the country.

- **Industrial waste**

The estimated generation of industrial waste is 250,000 t/y, of which about 150,000 tons are hazardous including 20,000 t of waste oils, although only 15,000 are collected.

- **Waste tires**

A generation of 15,000 t/y was estimated in 2012.

- **Construction and demolition wastes.**

Some 4 million tons of CDW are estimated to be produced in the country.

- **Agricultural wastes.**

According to GIZ, around 4 million of green and agricultural wastes are produced in the country annually as Tunisia is a big producer of organic agricultural products, especially olive oil, where the country is the third producer worldwide.

6.2.12.1.2 WASTE COLLECTION AND TREATMENT

MSW collection is covered at 80% in urban areas and 10% in rural areas. The country has a capacity of 1,788,000 tons per year MSW treatment distributed in 10 controlled landfills and four other semi-controlled ones with a capacity of 62,000 tons per year. Five discharges with a nominal capacity of 0.466 million tons per year are being built and five other controlled discharges with an average capacity of 0.433 million tons per year are planned. Many municipal landfills do not meet sanitary standards and waste is often dumped, being only five percent of MSW composted and 4% recycled. The expenditure for waste collection and transport constitutes 75-100% of the total solid waste management budget.

The country has environmental laws to encourage the sustainable management and recycling of municipal and industrial waste, but it is probable that the necessary measures for a good application have not been provided. The responsibility of waste management belongs to the National Waste Management Agency (ANGED).

Recycling activity is still very poor in Tunisia. Plastics are one of the most usual wastes produced in the country and there are almost 400 private companies authorized by the Ministry of Environment to collect, transport and recycle them. Five private collectors and recyclers of used tires were also authorized while paper and cardboard are hardly recycled yet. There is also a small informal sector for recycling food packaging.

Currently, there is a general thought in Tunisia that waste management should change towards an integrated management style which entails collection to treatment. The market for environmental protection, pollution control equipment and technology has significant potential, as anticipated tenders for landfills, coastal pollution project and waste water treatment all offer good opportunity for procurement.

6.2.12.2 TUNISIAN CEMENT SECTOR AND THE WASTE CO-PROCESSING STATUS

The cement sector in Tunisia was affected by a shortage of petcoke in 2015 due to the closure of the most important coke terminal so, they began to explore other fuels such as natural gas.

There are two cement plants owned by the government: one of them Is Ciments de Bizerte, and includes the largest petcoke terminal, and the other one is Ciments d'Qum El Kelil plant. There are other plants owned by multinational groups as Cimpor, Grupo Cementos Portland Valderrivas, Votorantim and, Secil.

Group / Company	Number of plants	Cement Production capacity (Million t)
Carthage Cement	1	2.20
Les Ciments d'Qum El Kelil (CIOK)	1	1.20
Les Ciments de Bizerte	1	1.50
Cementos Molins, S.A./ Sotacib Kairoun	2	1.40
Colacem, S.P.A. / Ciments Artificiels Italiens	1	1
Grupo Cementos Portland Valderrivas / Société des ciments d'Enfidha	1	2.10
Secil S.A. (Group) / Ciments de Gabès	1	1.3
Votorantim Cimentos Group / Cimenterie de Jbel Oust	1	1.8

TABLE 22. CEMENT PRODUCTION FACILITIES IN TUNISIA

Waste co-processing has not been developed so far, except a little use of biomass in 3 of the 8 integral cement plants in the country. Neverthelees, Colacem and Votorantim are interested in developing waste co-processing with olive oil wastes, mainly.

Import of AF is not allowed, and that is a serious restriction to start with co-processing, as in Europe there are quality AF in excess that could be used directly by the local cement industry while local pre-processing installations are built up.

6.2.12.3 SUMMARY

The information concerning waste management and waste co-processing situation in Tunisia is summarized in the two following slides:

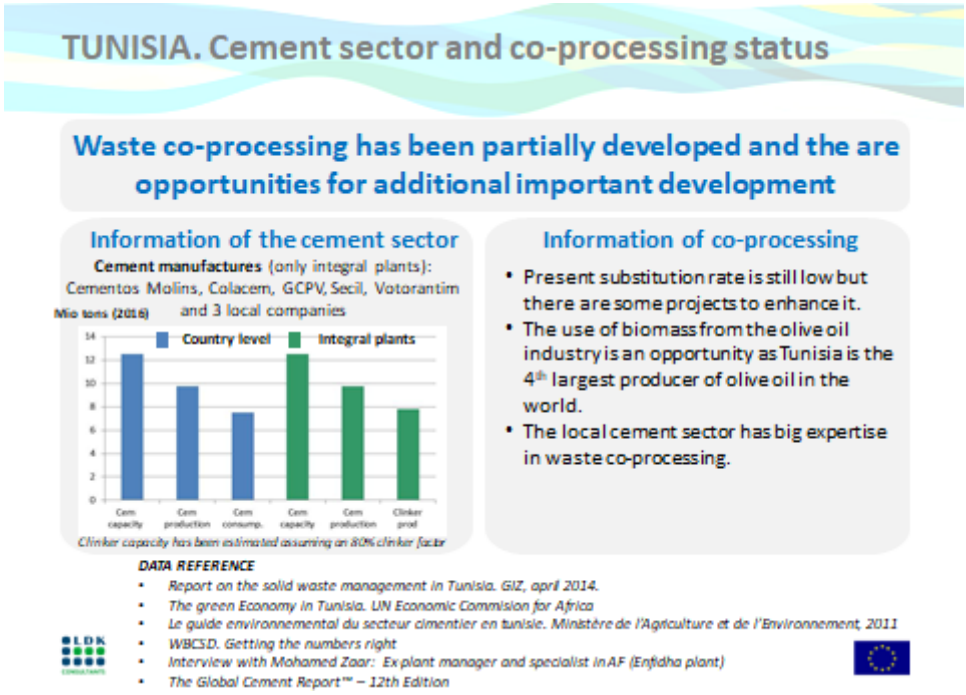


FIGURE 59. SUMMARY OF THE TUNISIAN WASTE MANAGEMENT AND CO-PROCESSING SITUATION

6.2.13 TURKEY

6.2.13.1 WASTE GENERATION AND MANAGEMENT STATUS

Waste management has shown a very significant development in the last 12 years, with increasing social and political sensitivity.

Turkey has two fundamental pieces of legislation to govern waste management:

- ✓ The Regulation on General Principles of Waste Management
- ✓ The Regulation on Solid Waste Control.

Implementation of programming has been slow, however, and capacity to develop comprehensive waste management systems is lacking.

According to the Turkish Statistical Institute, 113 controlled landfill sites, four incineration facilities, four composting plants and 864 other types of recovery facilities were in operation as of 2014.

6.2.13.1.1 TYPE OF WASTE PRODUCED IN THE COUNTRY

Available information on waste generation in Turkey offers different sight of the situation. Thus, a report issued in 2013 by the EEA on MSW in Turkey indicates that the 2010 waste generation accounts to 30 million tons of which about 25 million were collected (80%). The report considered that 98% of the total collected amount was landfilled, either in sanitary landfills or dumpsites.

Furthermore, another report issued by the Japan International Cooperation Agency in 2015 declared a MSW generation of 25,864 Million tons in 2012 based on Turkish statistics. Similarly, a lecture by a representative of the Turkish Ministry of Environment and Urbanization declared for 2012 the following figures based on Turkstat 2012:

- MSW generation: 25,845 Million t from which 71% is landfilled and 29% is dumped
- Used tires: 117.000 t
- Waste oil: 18.750 t

According to this source Turkey is in the process of following the European environmental regulations as a reference. National law on EIA establishes the public consultation on projects with relevant environmental impacts (eg. waste management projects, including RDF preparation plants or thermal processing facilities). According to Turkish national legislation, it is aimed that 60% of marketed products packaging waste have to be collected and recovered compulsory by 2020.

Targets on waste management are:

- 60% of packaging wastes recycled by 2020.
- Reduction of the biodegradable waste to be landfilled (25% in 2015, 50% in 2018 and 65% in 2025 vs 2005).

Recent information from the Turkish Statistical Institute offers additional information for 2014 and 2016 concerning waste generation and treatments as shown in Table 23.

The figures show that waste management has been improving along the last years due to the increase of treatment installations, both for disposal and recovery. Landfilling rate has decreased from 67,6% in 2014 to 56,7 in 2016, while the number of recovery installations has notably increased from 868 in 2014 to 1558 in 2016. Illegal dumping is prohibited and hazardous waste should not be landfilled in domestic landfill sites, and they have to be treated in few special landfill sites. Wastes must be treated according to the Waste Management Regulation.

Concept	2014		2016	
	tons	%	tons	%
Waste treated	61.048.878		77.208.662	
Landfilling	41.281.755	67,62%	43.815.135	56,75%
Incineration	42.882	0,07%	310.127	0,40%
Total disposal	**41.324.637**	**67,69%**	**44.125.262**	**57,15%**
Composting	94.019	0,15%	140.467	0,18%
Co-incineration	532.343	0,87%	738.908	0,96%
Other recovery treatment	19.097.879	31,28%	32.204.025	41,71%
Total recovery	**19.724.241**	**32,31%**	**33.083.400**	**42,85%**

TABLE 23. WASTE MANAGEMENT FIGURES IN TURKEY

On the other hands composting and co-incineration represent a minimum part within the waste treatment solutions in the country.

6.2.13.1.2 WASTE COLLECTION AND TREATMENT

Of the 28 million tons of waste collected by municipal waste collection services that year, 63,5% was transferred to controlled landfills, 35,5 % was disposed of in municipal dumping sites and 1 % was disposed of by other methods.

To meet universal waste management goals via the Waste Management Action Plan, € 2.1 billion of investment is needed between now and the 2023 goal deadline. The plan stipulates the development of regional solid waste processing and recycling facilities and sanitary landfills. In addition, € 1,9 billion of the action plan budget is to be allocated towards landfill creation and management, with the remaining directed toward plastics and packaging recycling facilities. Both Turkey's Climate Change Action Plan and the Waste Management Action Plan stipulate increased resource utilization through recycling.

Remediation and upgrading of existing uncontrolled landfills are major efforts the Government plans to undertake through the Waste Management Action Plan. The Ministry of Environment and Urbanization estimates that there are 1,400 of these sites, necessitating a € 350 million investment for closure and improvement. Full implementation of the EU Landfill Directive is expected to be carried out by 2025.

"National Recycling Strategy and Action Plan" is prepared, in order to find solutions to recycling problems and reach sustainable recycling system and effective structure. The steps are being taken to implement the economic size of the waste with National Recycling Strategy Action Plan that is considered as an important point to reach the vision of 2023.

6.2.13.1.3 PUBLIC AWARENESS

Turkey has repeatedly stated that it is taking into consideration the economic and social conditions of the country in protecting the environment, while the implementation of the national environmental legislation efforts are made for harmonization with the EU Environmental Acquis.

Several EU environmental and waste management directives **have been transposed** into Turkey's national legislation. In this sense, an extraordinary effort and an improvement in communication and cooperation between the government, local authorities and the public and private sectors are required if the proper implementation of this regulations is to be achieved.

Turkish Cement Association (TÇMB) has stated its commitment to Circular Economy and the communication effort to "divulgate" the paper "Contribution of cement sector to "Circular Economy"

These initiatives will contribute to enhance the social awareness on environmental issues in general and in waste management and waste co-processing in particular.

6.2.13.2 TURKISH CEMENT SECTOR AND THE WASTE CO-PROCESSING STATUS.

Turkey is the main cement producer in the region with an annual production in 2016 of 67,856,234 t clinker and 75,403,325 t cement.
(*TCMA. http://www.tcma.org.Tr/file/2016%20Bolgesel-eng-december.xls*)

The clinker is produced in 52 integral cement plants able to produce about 95 Million tons of cement annually. Global cement producers are present in the country as in shown in Table 24.

Group / Company	Number of plants	Cement Production capacity (Million t)
OYAK	7	21,6
Limak Holdings	10	13,14
Akçansa (Heidelberg / Sabanci)	4	9,49
AÇ Cimento	1	6,5
Çimsa (Sabanci)	6	6,0
Askale Çimento	5	6,0
Nuh Çimento	1	4,78
Çimentas	4	5,40
Vicat	2	5,15
Çimko	2	4,65
Votorantim Çimento	6	3,68
Medcem	1	3,80
Adocim Çimento	3	3,0
Kahramanmaras Çimento	1	2,0
Sönmez Çimento	1	2,0
Batiçim Cimento	1	1,80
Bartin Cement	1	1,50
Sançik Bilezik Çimento	1	1,40
Batisöke Çimento	1	1,38

TABLE 24. CEMENT PRODUCTION FACILITIES IN TURKEY
SOURCE: GLOBAL CEMENT REPORT. 12TH EDITION

Nevertheless, it should be emphasized that with such an important cement industry, waste co-processing only reached 3,86 % in 2016 according to Turkish Cement Association, although some plants have a quite interesting substitution range with alternative fuel, close to 30%. Moreover, in the Eastern part of the country co-processing has not been developed so far. With the only exception of used tires, waste import for co-processing is banned, what represents a serious restriction to the waste co-processing development. The range of alternative fuels used in 2016 is shown in Table 25:

Name of waste fuel	Quantity in tons
RDF	290.235
Wastewater treatment plant sludges and bleaching earths	96.476
Used tires	89.943
Packaging wastes – plastics, paper, cardboard	44.317
Contaminated wastes	42.854
Used oils	17.371
Wood and textile wastes	14.427
Liquid fuel wastes	7.709
Oily wastes	5.107
Petroleum refinery wastes	4.568
Solvent and paint sludges	447
Other	2.507
Total declared co-processed waste	615.961

TABLE 25. ALTERNATIVE FUELS USED IN 2016

The use of waste as alternative fuel requires a special permit granted by the Environment authority, according to a positive list criteria; nevertheless, it takes quite a long time to obtain the permit to carry out the co-processing activity in a cement plant, as there are multiple requirements that have to be satisfied before trial burns, besides the compliance with the emissions level. Some of them are the following ones:

- Weighing systems have to be installed.
- Quality control laboratory is required to measure different parameters: calorific value, heavy metals, Cl, F, trace elements, etc.
- Radioactivity measurement device and trained & certified staff
- A proper storage site is mandatory. It must have an impervious ground, leakage collection pool, roof for protection, roof against rain and all the necessary requirements, in order to be environmental friendly.
- Proper feeding system
- Continuous emission monitoring devices (including HF, HCl, TOC).

In some way, the permitting procedure is similar to Waste Incineration Directive of EU, although it is much easier:

- Permitting process steps are regulated (all time limits from legal texts).
- Trial burn min. 5 days at the target substitution rate (preferably at 40%).
- Trial burn report to be inspected and approved by Ministry of Environment in Waste and Emission Departments.
- Inspection by the License Department of Ministry of Environment.
- No deficiency in process, license granted.
- If deficiency in process, 90 days given to complete. License is granted thereafter.

After the trial burn, co-processing stops until granting the license. At least 3 months between the trial burn and granting the license.

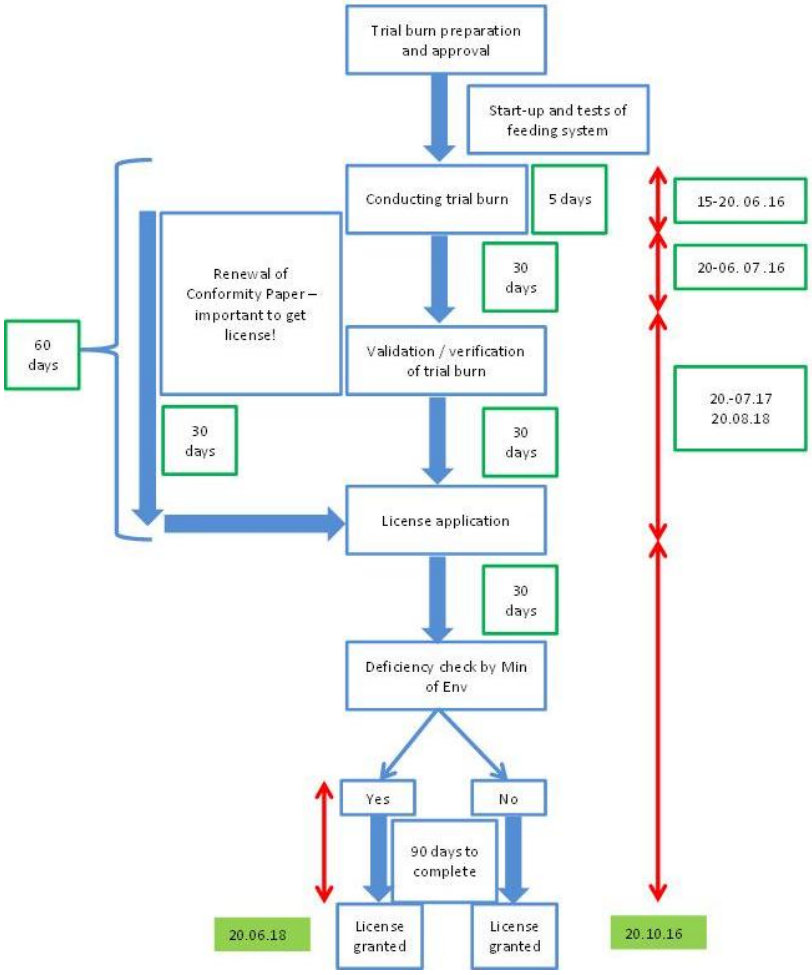


FIGURE 60: PERMITTING PROCESS IN TURKEY
SOURCE: VOTORANTIM TURKEY

FIGURE 61. CEMENT PLANTS IN TURKEY

While Western Turkey is more developed and industrialized, in eastern Turkey, beyond Ankara, no cement plant is using AF due to limited resources and other barriers. All high AF using companies have their own preparation facilities. AF average substitution rate in 2016 has been 3,86%.

Import of waste to Turkey is prohibited:

- ✓ EU waste codes 191210 and 191211* for RDF are banned.
- ✓ Similarly, 2619.00.90.00.11 customs code blast furnace slag importation is banned too..

Only 4004.00.00.00.13 (dust and chips from rubber) and 4004.00.00.00.19 (Others) customs codes are allowed (for shredded tires).

6.2.13.3 SUMMARY

The information concerning waste management and waste co-processing situation in Turkey is summarized in the two following slides:

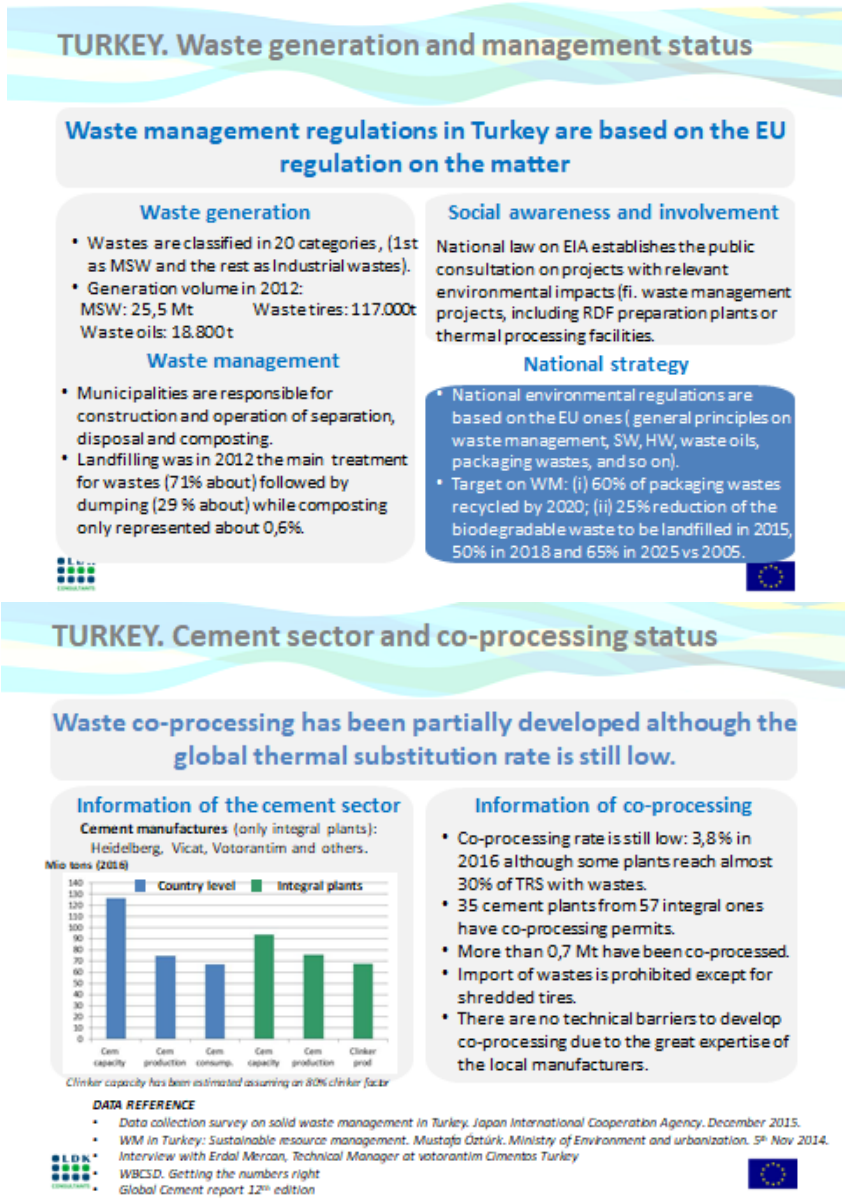


FIGURE 62. SUMMARY OF THE TURKISH WASTE MANAGEMENT AND CO-PROCESSING SITUATION

7 RECOMMENDATIONS FOR DEVELOPING THE WASTE CO-PROCESSING IN THE CEMENT SECTOR WITHIN THE MEDITERRANEAN

Waste co-processing in cement kilns has clear benefits for the country and for the local cement industry, but it is not an easy process to implement due to serious barriers already shown. According to existing experiences, mainly in Europe, it is almost impossible to develop this process without the Authorities support, a waste market organization and the local cement companies' commitment.

7.1 ENVIRONMENTAL REGULATIONS AND AUTHORITIES SUPPORT

The basic condition for co-processing development is a country regulation allowing this technique and the authority commitment to support it. Without a clear regulation framework is almost impossible to get legal certainty to plan co-processing investments and to get the operation permit.

The European regulation framework is a **clear reference for those countries interested in joining the EU as Albania or Turkey and** offers, in any case, a good guideline for other countries based in cooperation projects like the SWIM and Horizon 2020 SM.

CASE STUDY FROM OUTSIDE THE REGION: CO-PROCESSING SITUATION IN CHILE

Chile represents an interesting example for countries interested in the co-processing development in the cement industry, as it shows the result of both the authorities commitment and the public private partnership on the matter.

- From 1999 to 2003 the first preliminary co-processing permits were granted, without any specific regulation. Permits' scope was quite strict and the permitting process uncertain.
- In 2004 the Clean Production Agreement was adopted; it is a voluntary commitment of the industrial sector to fulfil standards beyond regulations.
- From 2003 to 2006 Chile decided to be a pilot country for the GTZ-Holcim collaboration project on waste co-processing in the cement industry. The GTZ-Holcim co-processing guidelines were communicated and promoted.
- In 2007 an emission rule on incineration and co-incineration was issued.
- From 2007 to 2008 a country rule for co-processing was developed.
- From 2008 to 2011, because of its public private partnership experience, Chile has volunteered to participate on the Basel Convention co-processing guidelines adopted in 2011 by the UNEP.
- In 2013 the old rule on emission is updated and co-processing in cement kiln is officially included.
- Nowadays a new regulation on manufacturer responsibility is under development and co-processing is considered as a recovery treatment. This, for sure, will enhance Social Education and communication to get public understanding.

National regulations should consider co-processing either as combined waste treatment process (recycling plus energy recovery, as in Chile (see box)) or at least as two different recovery processes: Recycling and Energy Recovery by means of co-incineration. This has been the European approach, so far, but clear differences have been established between Incineration (disposal) and co-incineration (energy recovery), in order to promote recovery operations.

A critical point in regulation is the import of waste. The European criteria has been based on the assumption that wastes for disposal must be treated locally according to the proximity principle, but the movement of waste for recovery is free and can be moved within the European territory in order to facilitate recovery treatments.

With the progressive restriction to landfilling in Europe, huge quantities of quality AF (essentially RDF) are produced by responsible pre-treatment companies, for which there is not enough demand. If national waste regulation in the targeted countries would allow the import of AF for their cement industry, the impact on social awareness and the local know-how on co-processing will improve drastically with a positive effect on future local developments.

7.2 LOCAL WASTE MARKET ORGANIZATION

Waste co-processing in cement industry requires a proper waste market organization. Although in Europe wastes difficult to manage were used as alternative fuels since the very beginning, nowadays the trend is clearly to use principally RDF derived from MSW as it has been shown in the case studies.

The use of MSW in the WtE process is also strongly recommended by the GIZ report already mentioned (Waste-to-Energy Options in Municipal Solid Waste Management), which is a Guide for Decision Makers in Developing and Emerging Countries.

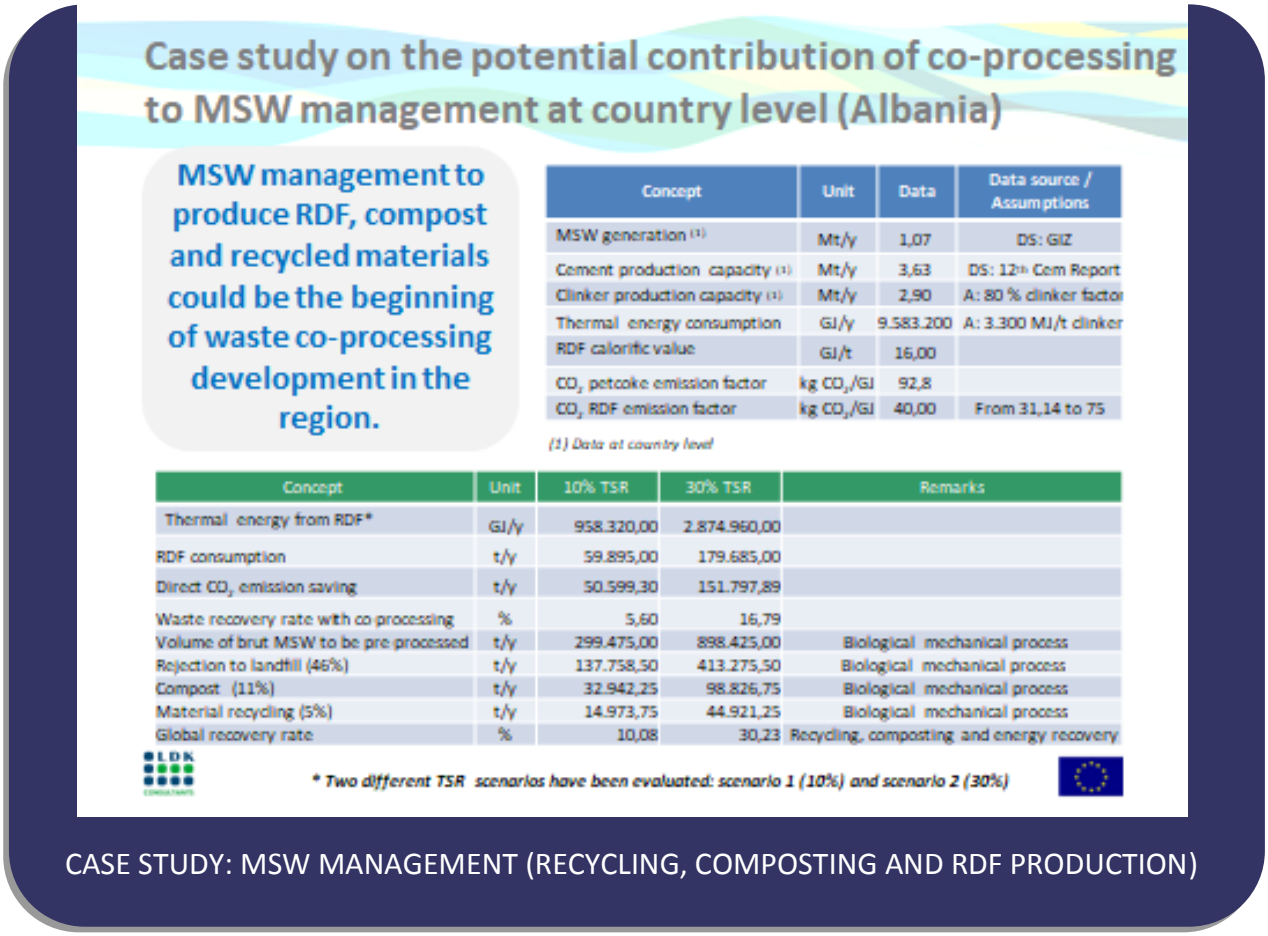
Based on the above reasons, the recommendation of the present report is to seriously consider waste co-processing in the target countries focusing primarily on MSW (where Recycling is not a viable option) and use them as the key source to produce RDF for the cement industry.

Furthermore, some additional waste streams, non-hazardous (such as packaging waste or waste tires) or hazardous (such as waste oil), can be used under favourable conditions to do so. Nevertheless, some requirements are considered essential for this process:

- Legal framework and environmental impact controls. A legal framework is necessary to provide legal certainty to relevant stakeholders that have to know their roles and obligations. It is just the case of administrative authorities, waste producers, treatment and disposal companies, citizens etc.
- Safety and environmental standards must be also well stablished and enforced and the result should be monitored by independent organisations.
- Knowledge on local waste characteristics: **WtE is only a part of the waste management** solution, so another treatment solution must be considered, planned and operated. The management system planning should take into account the waste characteristics, more wet in emerging countries than in industrial ones
- Financial aspects: Waste management infrastructures able to WtE development are not cheap compared to landfilling, so several options to generate income should be considered as

direct citizen fees, government subsidies, international organisation funds, revenues from recycled material, etc.

- Furthermore, to the general MSW infrastructure, some specific streams of waste require specific installations and separated waste management solutions, thus it would be the case of waste oil, used tires, etc.
- Based on national figures on MSW generation and cement production in one small country as Albania, the following Case Study shows a theoretical case study assuming the local cement industry contributes notably to the waste management by means of co-processing. RDF would be produced according to the biological-mechanical process already described in chapter 2.5.1



CASE STUDY: MSW MANAGEMENT (RECYCLING, COMPOSTING AND RDF PRODUCTION)

7.3 CEMENT COMPANY COMMITMENT TO SUSTAINABLE DEVELOPMENT

Assuming the country regulation allows co-processing technique, there is social understanding, enough to launch a project without high probability to be stopped, and waste market organization makes possible alternative fuel availability, the cement company must adopt an internal commitment to develop co-processing and follow the proper process to grant the project success. Based on the authors' experience the company approach shown in Figure 63 is recommended.

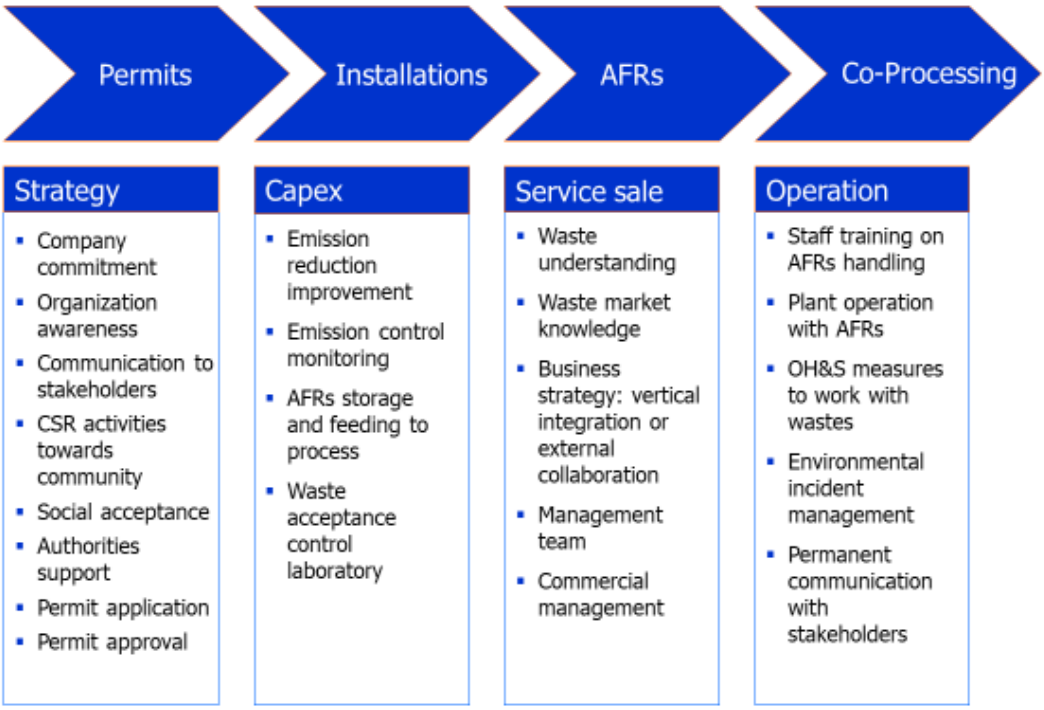


FIGURE 63. CEMENT COMPANY ROAD MAP TO DEVELOP WASTE CO-PROCESSING

7.3.1 COMPANY SUSTAINABLE DEVELOPMENT STRATEGY AND PLANT CO-INCINERATION PERMIT

According to experience, the key issue in waste co-processing development is the permit, as many subjects out the company control are involved and furthermore the cement companies need to implement a proper strategy, in order to guarantee the process success.

Although sometimes cement plants want to develop co-processing in an easy quick way, without public information and little internal awareness, pretending that there is only a fuel change. This approach is quite risky and counterproductive as it does not provide security for operation and furthermore it represents a risk for the image of the company.

The proper way to guarantee its success is to consider waste co-processing as a strategic matter based on a sustainable development approach, creating internal awareness and establishing an active communication plan to show stakeholders the benefits of co-processing and get their trust and involvement, in order to get the social license to operate. Corporate social responsibility activities with the local community and public affairs actions are quite convenient to create a positive relationship atmosphere with neighbours and authorities.

When the previous steps have been overcome, it is the proper time to apply for the permit and to get it without significant troubles or delays. Trying to get a co-processing permit when there are not proper conditions yet is a waste of time and could ruin or compromise future development opportunities.

CASE STUDY COMMUNITY ADVISORY PANEL

Social acceptance is a key point in environmental projects, but it is especially important in waste management ones. A practical and effective way to engage stakeholder and generate trust at local level is the constitution of a dialogue structure that receives different names, depending on companies or countries. Thus, Community Advisory Panel (CAP), Sustainability Committee, or in French "Comité Local d'Information et Surveillance" (CLIS). This initiative has proven to be very successful in cement plant when the factory was planning to start a co-processing project.

CAP is a communication tool towards the social factory neighbourhood. Its mission is to create mutual trust by means of a fluent dialogue among representatives from local stakeholders and the factory.

The reason for the CAP is the factory commitment to communicate and dialogue with its local stakeholders and main objectives are:

- To inform stakeholders on the factory operation
- To know and to discuss about relevant issues for the local community
- To be a suggestion and recommendation channel on factory activities
- To propose company CSR activities on the region.

Members of the CAP are normally:

- Factory staff: plant manager, environment manager, plant workers,
- Local stakeholders: municipality representative, NGOs, professors, local associations, neighbours
- Moderator: An external person with professional authority to be respected both for the factory and the stakeholders.

The CAP must be managed in a formal way, with regular meetings along the year, conducted by the CAP´s moderator; it must have a previous agenda and a later memorandum.

This initiative is an example of a proactive communication strategy that has shown to be much more effective than a traditional reactive behaviour and it is especially useful to prevent emotional opposition to excellent and sound environmental projects only because stakeholders do not have enough information and become easily concerned by NGOs or another groups' arguments about potential risks for safety and health.

7.3.2 CEMENT PLANT UPGRADE CAPEX

Waste co-processing in cement plants is usually covered by specific regulations, stricter than the traditional cement manufacturing ones. New requirements are needed on emissions level, emissions control and monitoring, and alternative fuels quality control, making necessary important investments on emissions abatement installations, such as higher efficient filters, SNCR installations for NOx abatement or some other equipment stablished by the environmental permit addressed to prevent or reduce environmental impacts.

Continuous measurement devices for monitoring additional pollutants can also be required according to the permit conditions and particularly, laboratory devices for controlling the AF characteristics are, usually, permit requirements.

Furthermore, new installations for AF storage and feeding to the kiln are also necessary. These installations must be designed and operated according to risk analysis procedures, based on the quantity and physical and chemical characteristics of the AF the plant is using. Examples of these installations have been described in chapter 2.5.2 of this report.

Normally, the environmental permit also includes requirements for waste water from rain (washing of external surfaces and runoff) and cleaning at the AF storage area.

As co-processing should have a positive contribution to the cement business, it is necessary to perform a global financial analysis, in order to show co-processing is cost-effective for the plant. The result depends very much on the country conditions; local costs of traditional fuels and electricity and, alternative fuels volumes and costs are the main factors to be taken in account.

7.3.3 COMPANY CO-PROCESSING BUSINESS MODEL AS ENVIRONMENTAL SERVICE

As already mentioned, waste co-processing is a service business and it is much more than a purchase function looking for additional fuels. **Deep knowledge on waste characteristics, waste market and waste management are essential but in addition clear decisions on the service business organization have to be taken.** There are two basic models: external collaboration or vertical integration, although a mix, of both of them, is also possible.

The cement company can decide to focus only in the final treatment process for available alternative fuels and to work in collaboration with local waste management companies that are able to pre-treat wastes and produce quality alternative fuels. This approach is possible either in developed countries, where the waste market is well established and there are professional waste pre-treatment companies, or in transition economies where the cement company decides to focus only on few alternative fuel families with little risk, as familiar agriculture wastes or used tires. This strategy is, in general, not recommended for developing countries when the cement plan wants to treat hazardous wastes, because of the risk of poor AF quality and possible pollution. In this case the infrastructure and staff requirements are low, but the risks are significant.

If the cement company decides to work directly with waste generators and to guarantee the high quality of AF entering its cement plant or when the waste local market is not well developed, the option **is to implement its own commercial waste service staff and pre-treatment installation**. This approach gives to the cement company security on waste flows availability and AF quality, although it requires a higher investment in installations and additional expenses in specialized staff.

The cement company can also start the co-processing activity according to a vertical approach and to establish later collaboration agreements with local professional pre-treatment waste companies or, on the contrary the company can start modestly working in collaboration and then enhance the service capacity creating its own pre-treatment installation and commercial service team.

Undoubtedly, for the countries of the region, the greater the responsibilities the cement industry undertakes, the better, particularly if the industry could guarantee the inclusion of proper treatment co-incineration of the toxic/hazardous wastes among the AFs.

7.4 CEMENT PLANT OPERATION WITH CO-PROCESSING

The waste co-processing in cement kiln necessarily represents a certain change compared to the traditional cement plan status: new installations that have to be properly operated, new risks that should be evaluated and prevented, new fuel with different characteristics that could have influence on the burning conditions, and others. So, co-processing means significant changes in the cement plant operation that should be well studied, known, monitored and properly managed. All these changes are controlled by the plant technical equipment and are included as one more activity in their quality, environmental and safety management systems.

The long experience with AF, in the cement industry allows finding plenty of examples of cement plants working successfully with very high rate of thermal substitution with AF but the learning process should be taken into account for any new plant starting with co-processing.

7.4.1 SAFETY MEASURES TO OPERATE WITH ALTERNATIVE FUELS

To guarantee waste compliance with all the acceptance requirements to use them as AF in the cement kiln, BREF document recommends the following techniques:

a) To implement and use quality assurance systems to achieve the waste specifications and comply with:
   - constant quality.
   - physical characteristics: emissions level, granulometry, reactivity, burnability, calorific value, etc.
   - chemical characteristic: chlorine, sulphur, alkali, phosphate, halogen and relevant metals content.

b) To control the amount of relevant parameters for wastes used as AF in the cement kiln, such as chlorine, sulphur, total halogen or relevant metals (e.g. cadmium, mercury, thallium) content.

c) To apply quality assurance systems for each waste load.

In order to ensure appropriate treatment of the wastes used as fuel in the cement kiln, BAT recommends following techniques:

a) AF feeding point: use appropriate points in terms of temperature and residence time. For instance, to waste materials containing organic components that can be volatilised before the calcining zone must be fed in the zones of the kiln system with high temperature, in a continuous and constant way.

b) Kiln parameters: in order to ensure that the gas resulting from waste co-incineration is raised in a controlled and homogeneous way, a temperature of 850 °C for 2 seconds has to be granted. Kiln temperature must raise up to 1100 °C when hazardous waste, with a content higher than 1 % of halogenated organic substances, expressed as chlorine, are co-incinerated. When the co-incinerating conditions cannot be reached, the co-incineration activity has to be delayed or stopped.

BAT applies safety management for the storage, handling and feeding of hazardous waste materials, such as using a risk-based approach according to the source and type of waste, for the labelling, checking, sampling and testing of waste to be handled. Moreover, local industrial safety rules must be taken into account, like firefighting installation or flammable material storage.

Furthermore, AF are wastes and sometimes hazardous wastes. So, according to AF characteristics proper OHS measures must be implemented, in order to prevent potential risks for workers, such as staff training in specific AF risks, personal protection equipment or medical tests.

It is also recommended to have an emergency plan implemented, to show everybody how to process in case of accidents with AF. This plan should be well known by the whole plant staff by performing drills periodically.

7.4.2 STAKEHOLDER ENGAGEMENT AND COMMUNCATION

Communication to stakeholders is the key point in any environmental project and definitively, it is in the case of waste co-processing in cement plants. While previous communication is necessary to get stakeholders trust, public reporting on results is a good tool to kept it. An annual environmental report or a wide sustainability report at company level can provide a company responsible image, that facilitates communication with stakeholders and develops their understanding, what means an efficient way for getting their involvement and enhancing their trust. Leader cement companies produce periodically sustainability reports that could be used as excellent guidelines for local cement groups in partner countries.

An interesting example of stakeholder engagement and public reporting specially in the co-processing field is the Cema Fundation's case study, following shown:

CASE STUDY: CEMA FUNDATION

Assuming that co-processing is the main contribution to a Sustainable cement industry and the social issue is the biggest barrier for a successful co-processing, the Spanish Association of Cement Manufacturers (OFICEMEN) and the two main Spanish trade unions, CCOO and UGT, through their respective Construction Federation, have decided to work together to promote co-processing within the sector and externally, addressing the main stakeholders and society as a whole.

To reach their purpose the parts have set up a tripartite foundation in 2005: The CEMA Foundation (Labour Foundation for Cement and Environment). Working areas of the foundation focused on the cement sector are: sustainability and CSR, communication and awareness, environment, energy recovery of waste, OH&S and training and education. The CEMA foundation became the consolidation at national level of a similar initiative born in February 2003 at regional level encouraged by the regional government of Andalusia through its Environmental department.

The CEMA Foundation has contributed since the beginning to create awareness on environmental matters in general and particularly on waste treatments and co-processing of waste in the cement industry by means of seminars, congress, lectures, articles, annual sustainability report and publications on circular economy, climate change, and status of waste co-processing. Furthermore

CEMA develops training initiatives addressed to scholars and students. The Foundation is a member of Forética (WBCSD in Spain).

Initiatives similar to CEMA Foundation are very appropriate in countries where society is reluctant to accept waste co-processing, as employees have more credibility than any other group and with their own testimony the can contribute to create trust in the local community which is the first step to get the social license to operate.

FIGURE 64. II ESR REPORT IN THE CEMENT INDUSTRY. SOURCE: F. CEMA

7.5 SPECIFIC RECOMMENDATIONS FOR THE TARGET COUNTRIES

Based on the specific country situation and taking into account regulation the trends and best practices in Europe, a summarized recommendation set has been prepared. Due to geographic, cultural and politic reasons the targeted countries have been grouped in the following blocks looking for synergies or for a common approach to co-processing development:

Region	Countries
Big cement producer countries at the region	Egypt Turkey
Northern African countries	Algeria Mauritania Morocco Tunisia
Middle East countries	Israel Lebanon Jordan Palestine
Balkan countries	Albania Bosnia Herzegovina Montenegro

TABLE 26. SEGMENTATION OF THE TARGET COUNTRIES

7.5.1 BIG CEMENT PRODUCER COUNTRIES IN THE REGION

BARRIERS	ACTIONS	
	EGYPT	TURKEY
Regulation	• To implement the National Solid Waste Management Programme supported by the EU and the KfW Development Bank that includes the main aspects on the waste management issue. • To develop additional frameworks necessary for implementing efficiently NSWMP. • To enforce the environmental and waste management regulations • To ban MSW and agriculture waste dumping.	• To enforce present environmental regulations inspired in EU, especially those concerning waste management. • To cancel the prohibition to import wastes to recovery, allowing AF import for co-processing in the local cement industry enhancing the current authorization, only for shredded tires. • To prioritize the treatment of wastes through co-processing in cement kilns over the electricity production due to the higher recovery rate of the cement process.
Social	• To start to develop Education for Sustainable Development (ESD) and citizen awareness on waste management from authorities implementing the MSESD and its Action Plan as this had not been considered so far, according to NSWMP and World Bank prescriptions. • To enhance main stakeholder consultation and engagement in all waste management planning and regulation.	• To guarantee the effective neighbouring participation on projects with important environmental impacts, according to the national law on Environmental Impact Assessment. • To educate population on Circular Economy Criteria, as the best way to get an environmental responsible behaviour. Implementation of MSESD and its Action Plan. • To divulgate and communicate, in a continuous and professional way, the commitment of the Turkish Cement Association with Circular Economy and the contribution of this technique to climate change prevention and sustainable development.

Waste management	• To enhance MSW collection and segregation. • To promote the use of specific agriculture waste as AF because of biomass nature and positive effect on climate change prevention • To promote from the waste management sector the waste co-processing as an important player within the country waste management infrastructure. • To develop a proactive attitude from the cement industry to society and institutions aimed to be considered part of the solution for the waste management issue in the country. • To develop collaboration between the cement sector and the public waste management sector to facilitate common project based on PPP approach.	• To consider the waste co-processing as an important solution within the waste management infrastructure of the country. • To prioritize waste co-processing over incineration • To close irregular dumps as they still represent a high volume of waste destination, around 30%. • Waste pre-treatment before landfilling should be implemented in order to produce RDF for cement industry and compost for agriculture, primarily in the Eastern country where industry rate is lower. • To implement a separate collection system for MSW.
BARRIERS	**ACTIONS**	
	EGYPT	**TURKEY**
Technical	• To build necessary pre-treatment facilities to produce quality RDF for the cement sector. • To develop some specific co-processing capability at cement plants for specific waste streams like used tires or dried sewage sludge. • To improve cement plants facilities to get better efficiency and build up co-processing installation suitable to consume important volumes of RDF, as MSW will be, at last, the most important and steady source for AF in the countrylike in Europe.	• Promote benchmarking in co-processing within the local cement industry, as there are some cement plants with a thermal substitution rate with AF up to 20%, while the country average is only 3,8%. • To take benefit of the presence in the country of cement global leaders as Heidelberg, Lafarge Holcim or Votorantim, with great expertise on waste co-processing to develop this technique at national level. • To build up MSW pre-treatment installations suitable to produce RDF mainly in Easter Turkey. This will represent an opportunity to reduce the external energy demand of the country and a sound solution for the MSW management in this part of the country.
Economic	• Economic incentives are needed to make feasible RDF production. • To increase landfilling fees to demotivate landfilling in favour of better environmental treatments. • To implement the Law 67/2010 on PPP to facilitate the development of the waste management infrastructure • The cost of inadequate WM is estimated between 0,4-0,7 % of GDP	• PPP and public incentives to new waste recycling and recovery installation should be considered to promote a sound solution to the MSW issue. • To implement a reasonable landfilling fee, to demotivate this disposal solution in favour of other more sustainable ones, such as recycling and energy recovery.

7.5.2 NORTHEN AFRICAN COUNTRIES

BARRIERS	ACTIONS			
	ALGERIA	MOROCCO	MAURITANIA	TUNISIA
Regulation	• To update the PRGDEM and PNAGDES, as they are rather old regulations, taking into account the Circular Economy criteria and the country commitment to the climate change. • To urgently ban dumping of wastes, based on health reasons and climate change criteria • To promote co-processing of waste as an effective technique to reduce country GHG emissions • To facilitate the permitting process on waste co-processing projects.	• To encourage and enforce PNDM (National Program on Household Wastes) and additional environmental regulations, as the current legislation status is enough to develop co-processing. • To reconsider the 2016 ban on AF import for co-processing, as it provides more flexibility to local cement industry. • To enforce waste oils' collection. • To facilitate the permitting process on waste co-processing projects.	Since the environmental regulations are old, the priority is to develop a regulation framework according to sustainable development criteria, working together with the support of international organisations.	• To effectively implement the National Strategy for a Green Economy (2016-2036) based on the former National Sustainable Development Strategy. • To develop environmental statistics and implement an integrated information system on the status of the green economy, involving all stakeholders, aiming to improve the understanding of the challenges and opportunities of the green economy. • To enforce the 'polluter pays' principle by strengthening environmental inspections and controls. • To remove the ban to AF import.
Social	• To continue the government commitment to environmental education and ESD at schools as the best way to increase environmental awareness and have responsible citizens with environment. • It is recommended that authorities share knowledge and experiences with other nearby countries with wide experience in waste co-processing, such as Morocco or Egypt.	• To develop Education for Sustainable Development (ESD) communication and awareness actions according to PNDM that has planned 2% of the project budget for this purpose • To engage stakeholders in co-environmental projects and particularly in any waste management project. • To create a community advisory panel for cement plants with co-processing operations.	• To solve other problems, such as poverty issues or water access are for sure priorities for Mauritanian society, more important than waste management.	• To enhance ESD communication and social dialogue around environmental challenges and green economy opportunities. • To integrate the green economy concept in the national education system.

BARRIERS	ACTIONS			
	ALGERIA	MOROCCO	MAURITANIA	TUNISIA
Waste management	• Waste co-processing should be considered as an important part of the waste management solutions in the country. • Landfilling of MSW without any kind of pre-treatment should not be allowed, so new landfills should be equipped with pre-treatment installations suitable to produce RDF.	• To encourage PPP to improve waste management infrastructures. • To close irregular waste dumping sites. • To encourage and support any waste pre-treatment project like those promoted by LafargeHolcim or Heidelberg.	• Main issue with MSW in Mauritania is the low collection rate and waste dumping, which should be the priority for the country.	• To prioritize MSW and agriculture waste as the main waste streams to develop co-processing, due to the high generation volume of both of them. • To consider the possibility of waste oil co-processing in case recycling solutions are not available, as the collection is well organized by a single company.
Technical	• Because of the importance of the public sector within the local cement industry, there is a big opportunity for GICA to lead the co-processing development in Algeria. • The important role of global players in the local cement industry is an asset to develop waste co-processing due to its high expertise on the matter. • Collaboration between GICA and global players in waste pre-treatment to produce AF for both groups would be an opportunity to develop waste-co-processing in the country.	• To build up a pre-treatment installation close to the main landfills to produce RDF from MSW, like Rabat, Agadir and Casablanca projects. • To develop co-processing installations for specific wastes streams such as waste oils.	• In the medium term, when waste collection and waste management is well organized there would be opportunities to pre-treat MSW and eventually produce RDF that could be exported to nearby countries with cement industry, assuming these countries allow import of waste for recovery. Morocco could be the best candidate due to the potential of its cement industry but so far it is impossible due to the present ban on waste import.	• To promote research and collaboration with the local cement industry, addressed to provide co-processing solutions to the huge volume of organic waste coming from the olive oil production, as Tunisia is the third worldwide producer. • To implement a pre-treatment installation to get recyclable materials, RDF for co-processing and quality compost for agriculture, according to the circular economy commitment of the country.

BARRIERS	ACTIONS			
	ALGERIA	MOROCCO	MAURITANIA	TUNISIA
Economic	• Due to the low cost of traditional fossil fuels there is no motivation to develop co-processing based on economic reasons, so government should provide economic incentives to develop co-processing based on climate change arguments. • To guarantee the feasibility of waste pre-processing and co-processing public economic incentives would be also necessary.	• To update waste collection fees, to finance the whole waste management chain. • To continue looking for funds from the World Bank, or other institutions as EU to help investment in waste management infrastructures.	• Finance helps from international organisations seem to be the only way to organize waste management sector in the country.	• To promote PPP to facilitate the contribution of the private sector to Eco innovation in order to develop the green economy and business competitiveness.

7.5.3 MIDDLE EAST COUNTRIES

BARRIERS	ACTIONS (MIDDLE EAST COUNTRIES)			
	JORDAN	ISRAEL	LEBANON	PALESTINE
Regulation	• To implement EU environmental regulations correctly as planned. • To allocate clear role and responsibilities on waste management at country level. • To get regulation enforcement. • To allow waste import for recovery, like AF for the cement industry. • To facilitate environmental permits for co-processing	• To effectively implement the environmental regulation based on EU legislation and push the National Planning and Building Board, which includes the MoEP's Waste-to-Energy (WtE) policy guidelines. • To remove present restrictions to waste co-processing (10 t/h and 40% thermal substitution with AF). • To facilitate the permitting process on waste co-processing.	• To implement effectively the Waste Management Plan of Ministry of SD and Tourism based on EU legislation. • To promote collaboration with the local cement sector and support it in the permitting process to develop waste co-processing. • To encourage PPP to create favourable conditions to invest in waste management infrastructures.	• To develop the legal framework; and enforcement of laws required to have a proper waste management. • To shorten and facilitate the permitting process of environmental facilities, including waste facilities.
Social	• To promote public consultation in accordance with EU EIA regulation. • To improve education on environmental issues and particularly ESD	• To improve environmental education/ESD at school and public campaigns addressed to general population to create awareness on Circular Economy. • To promote stakeholders' awareness by both the public and the private sector, in order to prevent co-processing rejection due to social contest.	• To Educate through ESD and create awareness about the possible solutions to the MSW crisis, including all kinds of potential sound solutions preferable to the present situation.	• Institutional building and improvement • To educate through ESD and develop training programs in the field of solid waste management for institutions and personnel who are working in this field.

Waste management	• MSW sustainable management should be the priority • Landfilling should be penalized in favour of more sustainable methods such as recycling or co-processing • To promote mechanical-biological MSW treatment producing quality RDF and compost for agricultural use.	• To accept co-processing as the best solution on waste to energy processes for reaching the objective of 23% energy recovery on MSW in 2030. • To promote PPP to build up waste management infrastructures.	• To focus to MSW management, as it is currently an important environmental and health issue for the country.	• To implement a good waste information system to have reliable data and a continuous environmental monitoring system.
Technical	• To build up pre-processing installations to produce RDF. • To use international expertise of Lafarge Holcim on waste co-processing to start the development of this technique at country level. • Thanks to its size the local cement industry could provide co-processing solutions to another nearby countries without cement industry, such as Palestine, assuming that they can pre-treat their waste and produce RDF.	• To prioritize the MSW pre-treatment installations to produce RDF for co-processing, instead of more sophisticated installations, as anaerobic digestion to produce bio gas. • To build up additional MSW pre-treatment plants like the Hiriya one, suitable to guarantee sufficient RDF to cover the cement industry needs.	• To build up new landfills equipped with pre-treatment installations suitable to recycle material and to produce both, quality compost for agricultural purpose and RDF for the cement industry.	• Facilities for waste management have to be controlled not only from the technical side but also from the environmental one.
Economic	• To look for funds from international organisations such as the World Bank, to develop waste management infrastructure and education campaigns on waste management.	• To set up a reasonable landfilling fee, enough to demotivate waste landfilling in favour of more sustainable solutions	• To look for international funds from the World Bank or other similar organisations, to facilitate the waste management infrastructure to cover the country needs.	• To increase waste recovery cost and also the collection fees and the cost of the treatment centre. • A new financial system and new funds will be needed to carry out waste management.

7.5.4 BALKAN COUNTRIES

BARRIERS	ACTIONS		
	ALBANIA	BOSNIA-HERZEGOVINA	MONTENEGRO
Regulation	• To implement EU environmental regulations correctly as planned. • To get regulation enforcement on waste management. • To allow waste import for recovery treatment operations, according to the EU rules. • To prioritize co-processing over incineration on the National Waste Management Strategy aiming to get 15% of energy recovery in 2025. • To force legally irregular dumps closure and prosecute legally infractions on the matter.	• To implement national regulation for Environmental Integrated Permits based on the EU legislation. • To set up obligation for separate collection in the national waste management system and enforce its implementation as it has been promoted since 2011. • To include all kind of waste streams into the waste management system. • To allow quality AF co-processing at the local cement industry.	• To implement effectively the Waste Management Plan of Ministry of SD and Tourism based on EU legislation. • To implement specific measures for hazardous waste management which generation seems to be growing without explanation.
Social	• To promote public consultation for environmental projects, according to EU EIA regulation. • To improve education on environmental issues/ESD.	• To insist on public education, EE and ESD campaigns to get population awareness on the risk for health and environment of improper waste management and to promote separate collection and waste recycling. • To use the social rejection on waste incineration in favour of recovery treatments as recycling and co-processing.	• To continue with public campaigns by the Ministry of Sustainable Development and Tourism to create awareness and systematically include EE and ESD into the school education programs. • To improve waste generation information.

BARRIERS	ACTIONS		
	ALBANIA	BOSNIA-HERZEGOVINA	MONTENEGRO
Waste management	• MSW sustainable management should be the priority, penalizing disposal operations and encouraging recovery treatments. • To implement a separate collection for MSW. • To ban MSW landfilling without a previous pre-treatment suitable to get materials for recovery like RDF. • To promote PPP to facilitate the building of MSW pre-treatment installations like mechanical-biological or bio-drying ones, in order to produce RDF for co-processing and reduce the volume of landfilling.	• To get public authorities promote waste co-processing, due to the commitment and capability of local cement industry. • To facilitate PPP to develop waste pre-treatment installations suitable to produce and supply RDF to the cement industry. • To ban MSW landfilling without any kind of pre-treatment.	• To set up priority on MSW management. • To enhance collection of MSW. • To implement any kind of solution for mining wastes in order to prevent contamination risks.
Technical	• To build up pre-processing installations to produce RDF from MSW. • To support the implementation of hazardous waste professional collection and specific treatment installations.	• To implement landfilling sorting and recycling capability to produce RDF for co-processing and minimize the volume of landfilled waste.	• To build up waste management infrastructure according to the National and local Waste Management plans.
Economic	• To set up a reasonably high landfilling fee that demotivate landfilling and facilitate recovery treatments, as recycling or co-processing. • To look for international organism funds to build up waste treatment installations and perform public education on sustainable waste management issues.	• To set up a reasonable fee for waste collection, enough to afford a correct and sound treatment. • To get funds from international organisations aimed to promote development as the World Bank, to facilitate investment in waste management infrastructures.	• To search international funds for developing countries and promote PPP.

8 CONCLUSIONS

- **Local environmental regulations committed to Environmentally Sound Management of wastes, based on Circular Economy principles and Climate Change policies, are the key issue for co-processing development**.
- Adoption of appropriate Emissions limits, law enforcement and active authorities support are as important as environmental regulations.
- Population awareness and stakeholder involvement, Education for Sustainable Development and communication are strongly recommended, in order to prevent social opposition that can ruin promising and sound co-processing projects.
- Private Public Partnership is a big opportunity to develop faster the waste management market.
- The development of waste co-processing in target countries under this report is not a technical issue, because of the high involvement and expertise of international cement companies operating in the region and some other local companies deeply committed to the subject.
- Local waste markets development is necessary for co-processing. Meanwhile the import of quality AF from the EU could help to develop it, assuming it is legally and socially accepted, what is not the case in many countries.
- **Local RDF production from MSW is the main opportunity due to the huge potential contribution to local waste management.**
- Additional waste streams as, waste tires or agricultural waste should be also considered, country by country.
- Cement co-processing also offers a unique opportunity to treat hazardous waste in the cement kilns in an environmentally sound, safety and cost-effective way.

9 ANNEXES

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9.2 INTERVIEWS WITH KEY ACTORS

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- Dimas Vallina. Managing Director of Fundacion Cema (SPAIN). 13.04.2018
- Amit Marmur: Nesher Cement Company (Israel) 10.05.2018
- Esther Valdivia: Environmental Director of Inerco (Spain). 18.05.2018
- José María Oteiza. Circular Economy Foundation (Spain). 28.05.2018
- Andrés Jensen. Corporate Sustainability Manager in Grupo Disal (Chile) 28.05.2018
- Andrej Rutkovsky: AF process engineer North Africa region (Lafargeholcim). 06.06.2018
- Rachid Seffar and Vincent Teissier: Head of EMEA Region Geocycle 08.06.2018
- Pedro Rodríguez. Engineering Director at INERCO (Spain). 19.06.2018
- Luis Palomino, Manager of ASEGRE (Spanish Association on Hazardous Wastes). 22.06.2018
- Juan José Riesgo: Business Developer in FLSmidith (Spain). 29.06.2018
- Mohamed Zaag: ex-Enfidha Plant Manager (Grupo Cementos Portland Valderrivas in Tunisia) and current consultant. 04.07.2018

- Elena Bronchalo.Basel Convention Representative in Spain. (Spanish Ministry of Ecologic Transition) 17.07.2018
- Jorge López. MSW plant manager at Ferrovial (Spain). 18.07.2018
- Luis Martínez Centeno. Director de la Planta de Cervera del Maestrazgo (Spain) 30.08.2018