“Optimal Recovery of material and energy resources: the cases of the rest fraction of municipal waste and sewage sludge”

Report based on the International Experts Seminar
Prepared by Hara Xirou, ACR+ Secretariat

16-17 June 2010, Seville, Spain

ALL PRESENTATIONS FROM THE INTERNATIONAL EXPERTS SEMINAR ARE AVAILABLE ON THE ACR+ WEBSITE: http://www.acrplus.org/Seminar-Sevilla-2010

Table of Contents

1. Introduction

This experts seminar was organized in the framework of a partnership between ACR+ (www.acrplus.org) and Holcim (www.holcim.com). This partnership aims at feeding the debate and identifying the best practices in link with the optimal management of resources in the context of waste management policies. It intends to explore legal and technical solutions in link with multiple policy developments at international level, namely:

- at UN level: United Nations Environment Program (UNEP) / Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, Conference of the Parties (COP) Climate Change.

- at EU level: new Waste Framework Directive, Post-Lisbon developments, EU 2020 objectives, new EU Framework Programme for the Environment and revision of several EU Strategies.

Objectives and format of the seminar

After the first Seminar which took place in Turin on 9 December 2009, the one that followed was organised in collaboration with the Andalusian Government on 16-17 June 2010 in Seville and focused on two specific waste flows: residual fraction of municipal waste and sewage sludge.

The seminar gathered a group of experts in order to discuss the issue of developing integrated approaches for specific waste flows through different waste treatment alternatives such as recycling, co-processing and energy recovery, with a view of reducing the consumption of material and energy resources and GHG emissions.

This report aims to present the issues raised when focusing on 'waste co-processing' at the level of cement production; such as existing European and national Regulations (i.e. Waste Incineration Directive), the materials identified to be used in such a process as well as the technologies available in order to achieve higher efficiencies in relation to CO_2 and energy balance.

1.1. Waste Policy at European Level

J.-P. Hannequart, President of ACR+ presented on the current new EU political orientation for waste management focusing on the residual fraction of municipal solid waste (MSW) and sewage sludge. All 27 member states have now adopted a legal EU five stage **waste hierarchy** [1]and following a top down approach of the waste hierarchy it is important to identify that level of waste hierarchy where co-processing can be applied.

Prior to the analysis of the role of co-processing in waste management operations, the new EU recycling targets (Appendix 1) are putting more pressure on EU member states to improve the separate collection of materials for recycling and re-processing.

In order to comply with the objectives of the Waste Framework Directive (Art. 11.2), and move towards a **European Recycling Society**[2] with a high level of resource efficiency, Member States shall take the necessary measures designed to achieve the following targets:

(a) by 2020, the preparing for re-use and the recycling of waste materials such as at least paper, metal, plastic and glass from households and possibly from other origins as far as these waste streams are similar to waste from households, shall be increased to a **minimum of overall 50% by weight;**

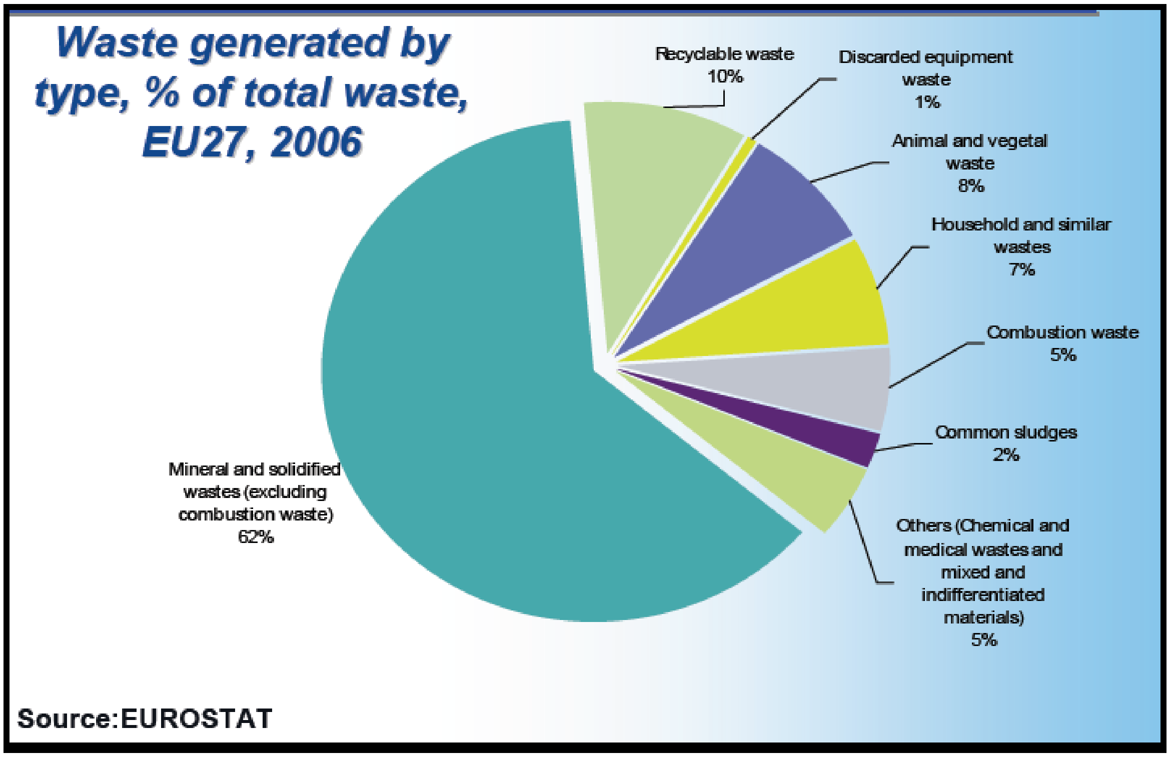
(b) by 2020, the preparing for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste excluding naturally occurring material shall be increased to a **minimum of 70% by weight;**

The total waste production and composition as presented by EUROSTAT (2006) demonstrates that household and similar waste account only 7% of the total waste whereas recyclable and common sludge waste account for 10% and 2% respectively.

---

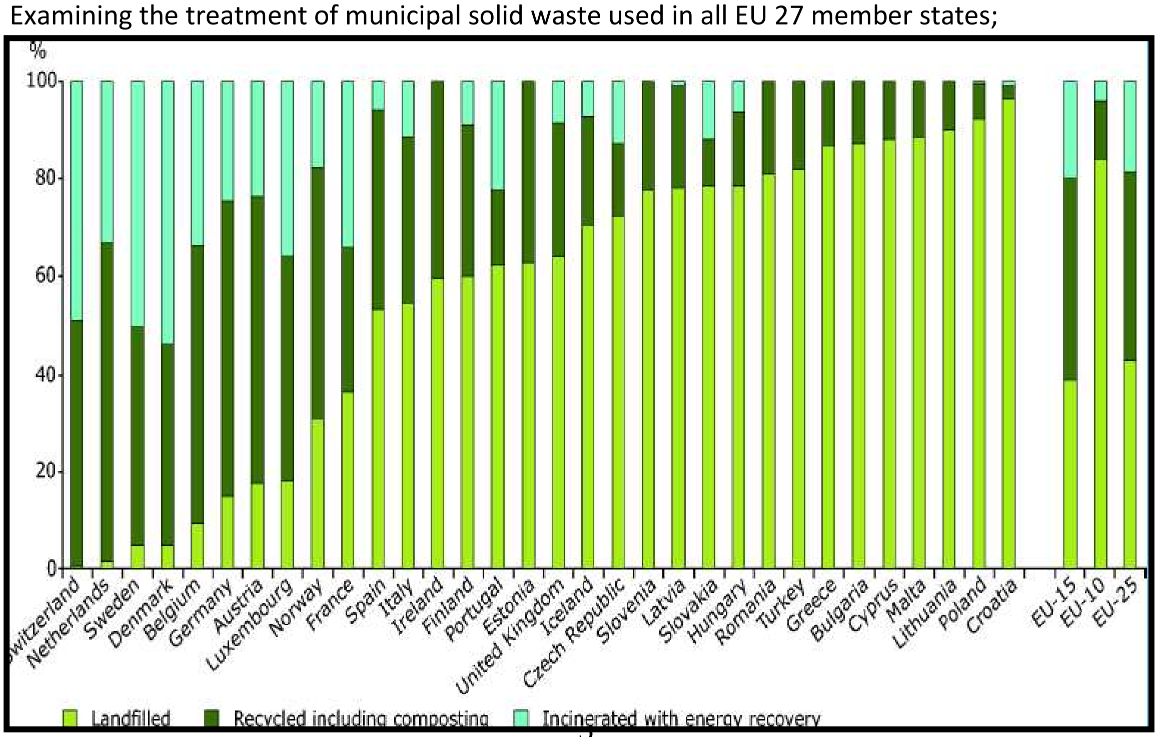
[1] Waste Management Hierarch: EU Directive 2008/98/EC Waste

[2] European Recycling Society: EU as a recycling society - Present recycling levels of Municipal Waste and Construction & Demolition Waste in the EU", ETC/SCP April 2009



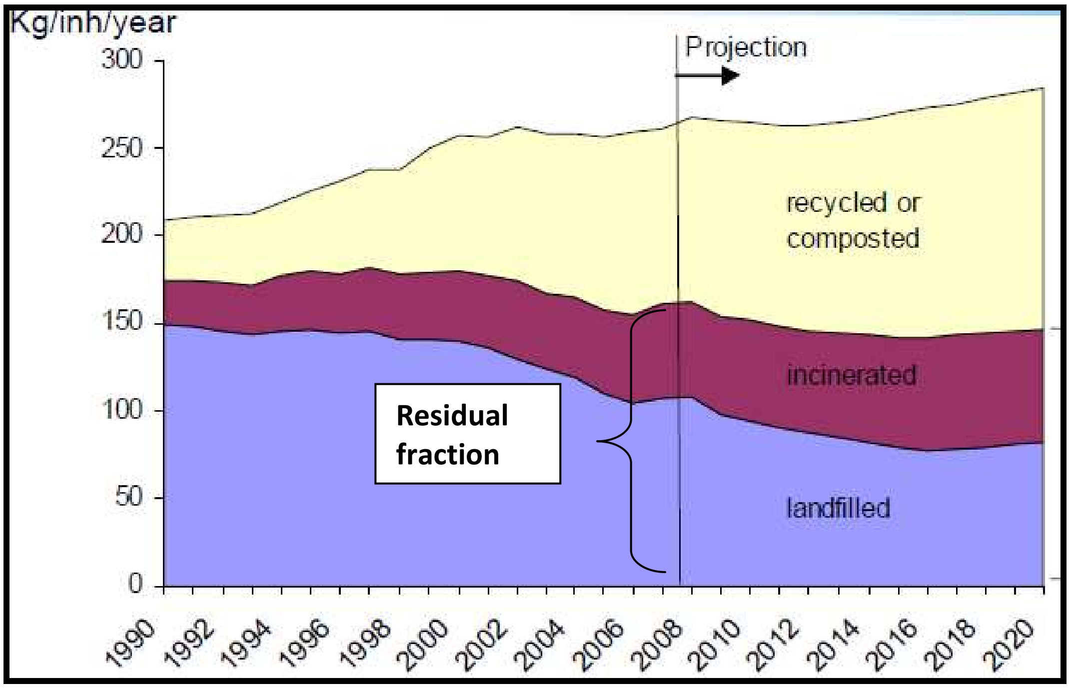
However, it remains still a key of topic of discussion the lack of common definitions in relation to waste terminologies (i.e. municipal solid waste) and variance in methodology used in calculating the recycling performance amongst different EU member states.

Examining the treatment of municipal solid waste used in all EU 27 member states;



Source: EUROSTAT

It is key for this study and for the role of co-processing to identify the percentage of residual fraction calculated from these treatments. The table below indicates that the amount of waste either sent to landfill or incinerated is decreasing throughout the years and will continue to do so whereas the amount of waste sent for recycling or composting is increasing and will rise further with the tight EU target of the WFD. **Therefore, the question here is 'Will there be sufficient amount of residual fraction to be used in co-processing and subsequently for cement production in the coming years?'**



Aside from the production and utilisation of residual fraction of municipal waste in cement production, the second waste flow examined in this seminar was: sewage sludge. The use of sewage sludge in co-processing operations can be of great advantage for energy production and material recovery.

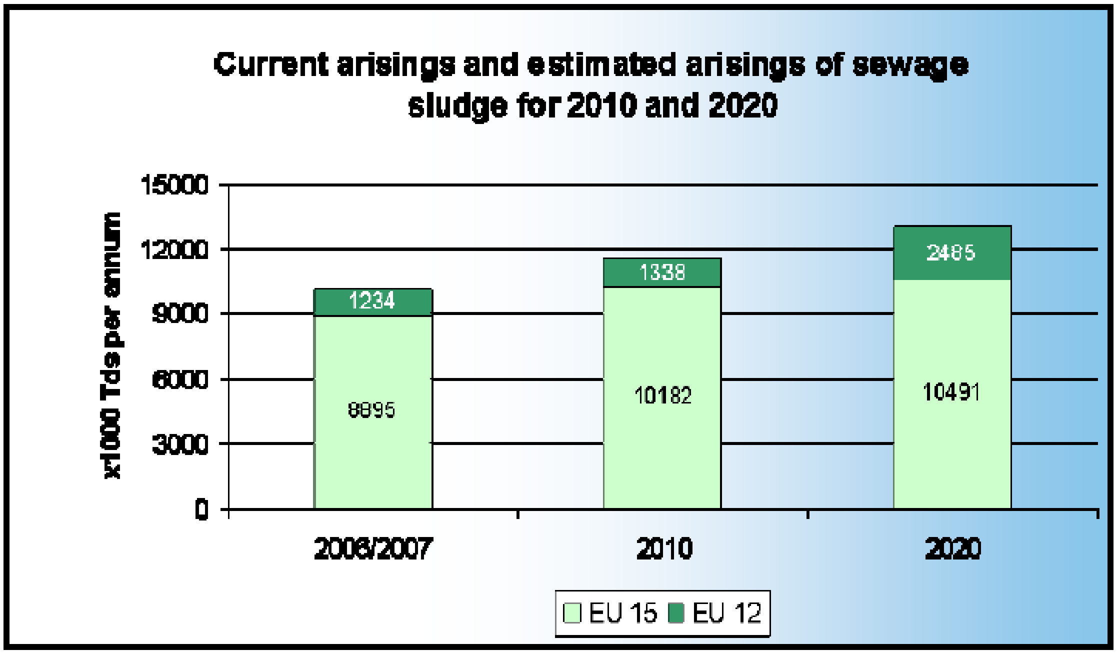
The Sewage Sludge Directive (86/278/EEC) was adopted more than 20 years ago with a view to encourage the application of sewage sludge in agriculture and to regulate its use as to prevent harmful effects on soil, vegetation, animals and humans. In the light of the increased production of sewage sludge across the European Union with the implementation of the Urban Wastewater Treatment Directive, and recognising the need to assess recent scientific research on the reuse of sludge in agricultural soils, the European Commission is currently considering whether the current Directive should be revised[3] by:

- assessing environmental, human and animal health risks from the application of sewage sludge on agricultural land
- preparing a baseline scenario in terms of policies and practices across the EU for the next 10 years
- identifying policy options for the policy revision of the Directive 86/278/EEC
- implementing cost/benefit analysis of the different options

Although the overall proportion of sludge recycled to agriculture across the EU has increased slightly since 1995, the situation in some Member States has changed dramatically: the Netherlands, for example, has stopped the recycling of sludge to land, and incinerate instead, while the UK and some other Member States have significantly increased the amounts used on land. In the EU15, incineration is at present the main alternative to spreading on land; in the EU12, it is still landfilling. In both groups, however, the variation among individual countries is quite large.

On the basis of a review analysis of EU legislation, together with a review of possible developments in the Member States, as well as developments related to climate change policy and renewable energy, sewage sludge levels will continue to rise within the EU27 (Appendix 2). On the basis of these trends, it is estimated that sludge production in the EU27 will reach about 11.5 million tons (dry solids) in 2010 and rise to just under 13.0 million tons in 2020. Overall, in the baseline scenario the proportion of treated sludge recycled to agriculture across the EU will remain more or less the same, at 42% in 2010 and 44% in 2020.

[3] Source: http://ec.europa.eu/environment/waste/sludge/pdf/part_i_report.pdf



Source: 'Environmental, economic and social impacts of the use of sewage sludge on land' (Report by Milieu Ltd, WRc and RPA for the European Commission)

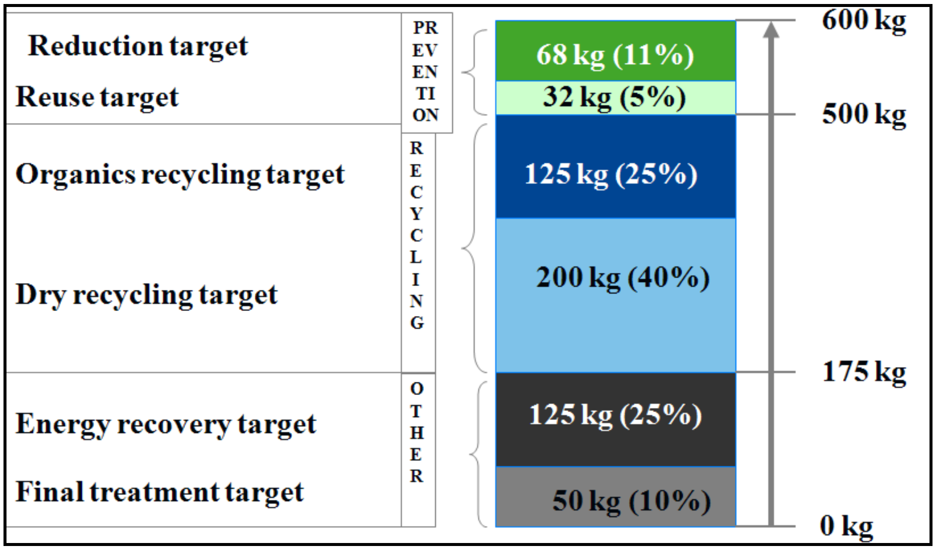
The use of the rest fraction of municipal waste and sewage sludge in co-processing operations can lead to high environmental impacts such as the release of GHG emissions in the atmosphere. For this, we need to examine very closely the CO_2 and energy balance as key criteria when assessing different waste treatment processes.

Waste disposal account for 2.8% of the total greenhouse gases (GHG) emissions in the EU27. EU-27 greenhouse gas emissions resulting from waste were estimated to be 141.2 million tonnes of CO2 equivalents in 2007. Of this, the majority resulted from landfill activities (emitting methane), while the handling of domestic and commercial wastewater was also a relatively important source[4].

If waste volumes at EU level were stabilized at 2006 levels, 1.1 billion tonnes of CO_2 equivalents would be saved by 2020. Therefore, binding minimum EU recycling targets of 50% for municipal waste could save more than 89 million tonnes equivalent.

[4] Using Official Statistics to calculate Greenhouse Gas emissions – a statistical Guide, EUROSTAT 2010.

It is essential to clarify the targets for municipal solid waste. ACR+ think that the following targets could be considered as optimal concerning the different modalities of municipal waste management:



1.2 Waste co-processing towards a legal EU recognition

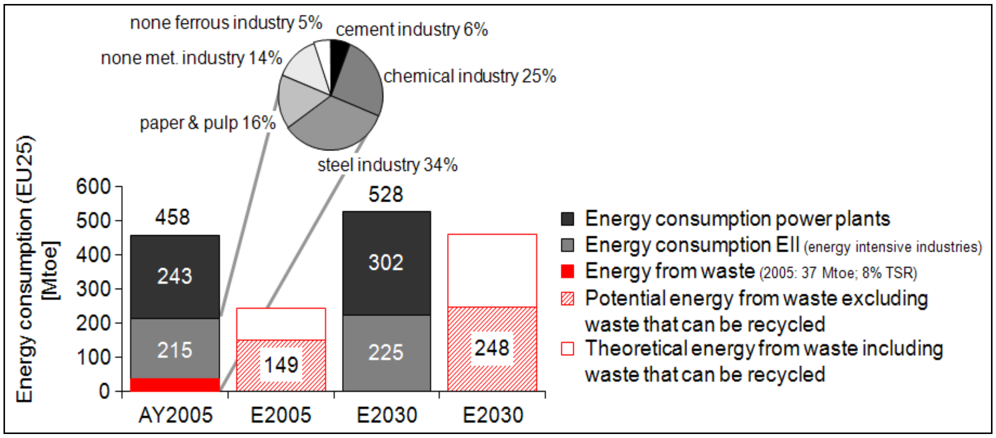
Worldwide cement demand increases by roughly 2% per year leading to equivalent increases in energy and raw material needs (Appendix 3). The business impact for cement is higher than for competing products (i.e. steel, aluminium, concrete). The CO_2 emission per unit of production is relatively low in comparison to virgin aluminium and steel production (Appendix 4). Therefore, cement production through the usage of sewage sludge waste and the rest fraction of MSW is an activity of '*co-processing*'.

Co-processing is the use of waste materials in Resource Intensive Industrial processes such as cement, lime, steel glass and power generation[5].

Current waste management practices leave a substantial part of the resource potential of waste unused. Estimates indicate that world-wide up to 8.5 billion tons of waste is

[5] Definition by Holcim, Jean-Pierre Degré (Vice President AR of Holcim Group Support Ltd)

discarded each year. Despite all the efforts to minimize waste, more than 80% is currently landfilled, dumped or burned illegally, contributing to pollution and not accessible for energy intensive industries.



Source: HOLCIM (2010)

According to Holcim's approach, Co-processing is positioned in the waste management as a preferred option to disposal systems. It highlights that when recycling of materials is not viable, co-processing of resources (i.e rest fraction of municipal waste and sewage sludge) should be selected.

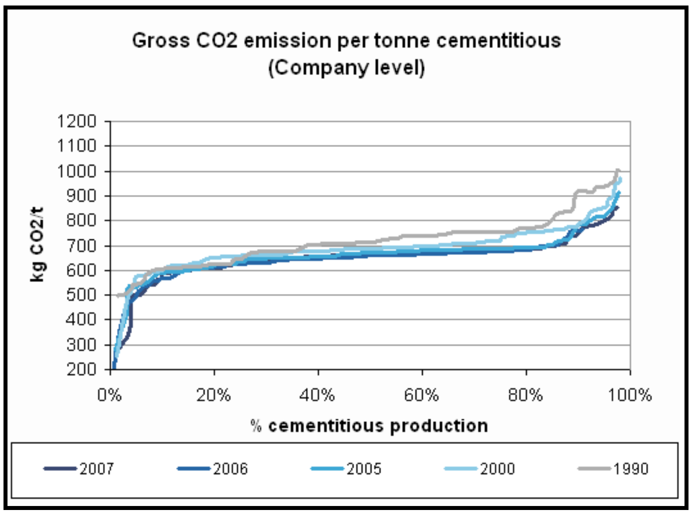
If co-processing is not applicable, then other waste disposal activities should be considered such as incineration or landfilling. Various countries are already in favour of potential cooperation for the implementation of specific guidelines for co-processing (US, Mexico, Chile, India, China, Indonesia, Australia).

Holcim and other private and public companies as well as NGOs are aiming to achieve a legal recognition of co-processing as a step of its own in the 'waste hierarchy' as defined in Article 4.1 of Directive 2008/98/EC.

2. CO2, Energy and material balance of waste treatment alternatives

2.1 Technology Innovation in the Cement Industry & the SET-Plan

When defining co-processing as the use of waste materials in resource intensive industrial processes such as cement, lime, steel and other we need to seriously consider the level of intensity of those energy intensive processes. In Europe, from 1990 to 2007 there has been a decrease of gross CO_2 per tonne cementitious product (8.8%) amongst other processes however EU policies and targets are putting more pressure for higher innovation in the energy intensive industrial sector.



Source: GNR Database System

Following the EU Energy and Climate Change Policy[6] to meet the ambitious target of decarbonising the energy system by 80% by 2050, a series of new technologies will require to be developed in the coming years. The EU Strategic Energy Technology Plan (SET-Plan) is the technology pillar of the EU's energy and climate policy. It has been adopted in 2008 by the European Council and Parliament as the EU response to accelerate the development of a world-class portfolio of affordable, clean, efficient and low emission energy technologies through coordinated research efforts.

[6] The EU Energy and Climate Change policy encompasses; reduction of GHG emissions, security of energy supply and increased competitiveness

The SET-Plan[7] is currently in its implementation phase, moving towards the establishment of large scale programs such as the European Industrial Initiatives (EIIs) that bring together industry, the research community, the Member States and the Commission in risk-sharing, public-private partnerships on the development of key energy technologies at the European level. Six priority technologies have already been identified as the focal points of the first EIIs; amongst those are: electricity grids, bioenergy, carbon capture and storage and sustainable nuclear fission.

So far, there does not exist such a comprehensive R&D, technology master plan for the energy intensive industrial sector equivalent to the energy supply sector in the framework of the SET-Plan. However, in recent years, new public private partnerships have been set up in various fields (i.e. for energy-efficient buildings) that relates to energy intensive industries using different instruments and legal bases.

"*Further Industrial Initiatives may be necessary, and therefore the Council encourages the Commission to continue to examine areas with great potential such as marine energy, energy storage and* ***energy efficiency*** *for this purpose*." European Council, April 2008

Currently the Information System of the SET-Plan (SETIS) is exchanging with the stakeholders on the current role of technology innovation in the improvement of energy efficiency and reduction of CO_2 emissions in the Cement Industry, the anticipated technological development and market potential as well as exploring potential actions in the context of the SET-Plan.

Amongst a list of requirements to decarbonise the energy system by 80% by 2050, is the:

- encouragement, facilitation and increase use of alternative fuels (waste and biomass)
- facilitate the development of CO2 capture and storage
- investment of current-state of the art technologies
- Enhancement on R&D of capabilities, skills and innovation
- promote international collaboration and public-private partnerships

[7] SET-Plan: http://ec.europa.eu/energy/technology/set_plan/set_plan_en.htm

One of the main challenges to reach the ambitious targets and lead countries to low carbon economies in this sector would be the achievement of higher rates of fuel substitution as there are stronger political and legal barriers that technical ones related to waste legislation, waste collection, competitive fuel market and social acceptance.

2.2 LCA of integrated Waste Management Systems

The following section is part of a presentation given by Gian Andrea Blengini**,** Senior Researcher at the *Politecnico di Torino* where he leads the Life Cycle Assessment (LCA) research group. Dr Blengini and other specialists in favour of Life Cycle Assessment state that LCA is a very effective instrument to asses and compare waste treatment processes. He considers that LCA is an objective tool for analyzing and quantifying the environmental impacts of a product or activity (a system of products) over its entire life cycle: from the extraction of raw materials, through industrial production, including the use phase and the end of life disposal.

LCA modelling of waste management systems is a complex issue and the subsequent analysis is complex too. Developing waste management strategies is a delicate task which encompasses several aspects that cannot be fully included in a LCA analysis. Moreover, the research programmes recently carried out for Torino and Cuneo Districts have once more confirmed that there are not preferable waste management solutions in terms of all the indicators[8]

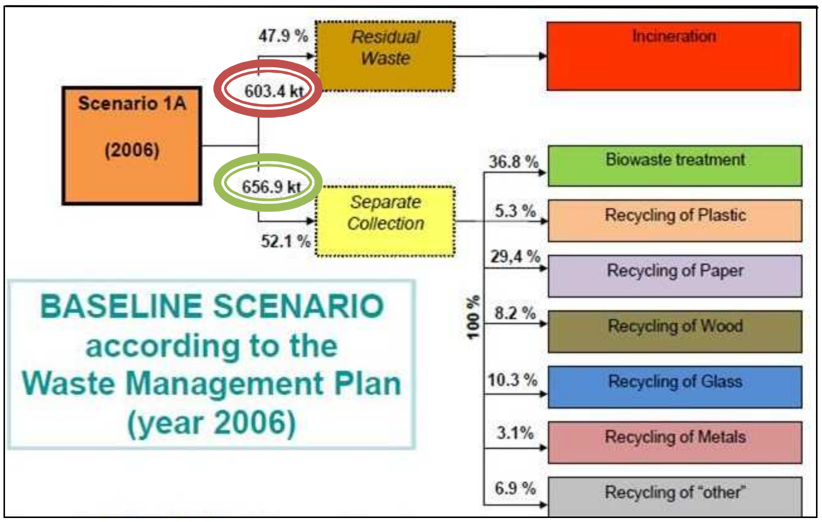
As far as waste management is concerned, a life cycle approach is warmly recommended, as the environmental implications of most waste treatments fall outside the physical boundaries of plants and facilities. Thus, indirect (but inter-dependent) environmental consequences fall outside the control of waste operators. It is thus very possible that solutions focused on a specific environmental issue may cause worse environmental consequences upstream or downstream, or adversely affect an inter-dependent waste management chain.

[8] Blengini G.A., Genon G., Fantoni M., (2009) LCA del sistema integrato dei RSU nella Provincia di Cuneo. Research programme financed by "ATO-Rifiuti Cuneo - Associazione Ambito Cuneese Ambiente", 47 pp.

Impact of separate collection and recycling

LCAs based on real waste management chains and site specific data confirmed that separate collection and subsequent recycling is the most effective tool to improve energy efficiency and to lower environmental impacts[9]. This conclusion was drawn after considering the whole sequence of activities in the chain, thus quantifying the eco-balance of collection, transportation, selection, recycling of the main flows and landfill/energy recovery of rejects.

LCA of the IWMS of Torino District: Baseline scenario



Source: Gian Andrea Blengini (Torino Politechnic, Italy)

The baseline scenario above shows that higher energy efficiencies (in kt) are reached when carrying out separate collection (656.9 kt) with recycling/composting than sending residual waste for incineration
(603.4 kt).

The research has also highlighted that there is room for improving efficiencies along the collection-recycling chain, which is presently not fully optimised.

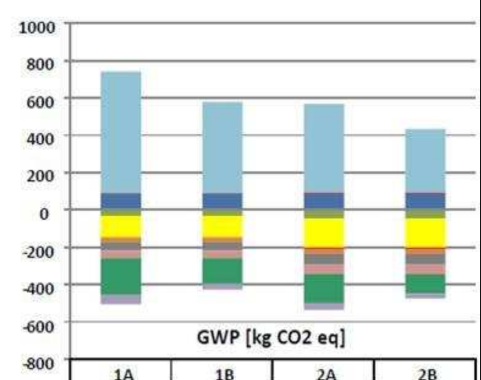
[9] Blengini G.A., Genon G., Fantoni M., (2009) LCA del sistema integrato dei RSU nella Provincia di Cuneo. Research programme financed by "ATO-Rifiuti Cuneo - Associazione Ambito Cuneese Ambiente", 47 pp.

Different strategies for energy recovery from residual waste

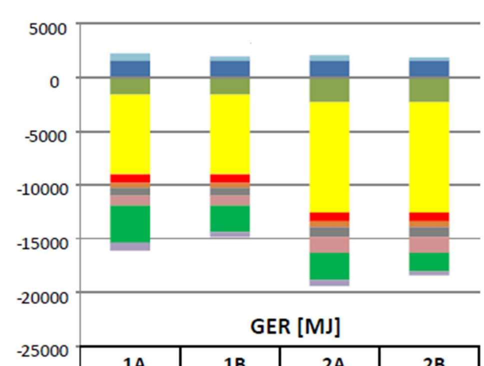
LCA can supply objective and comprehensive information, but, in Italy, the final decision lies entirely with public administrators seldom aware of the great potential of LCA. Such public administrators often set up priorities more on financial constraints rather than on environmental optimisation issues. However, it is also the responsibility of LCA experts to work in co-operation with public authorities to ensure that all parties understand LCA studies and put into practice the results.

Based on the mass balance of real chains, site specific data and local operational conditions, it emerged that co-incineration corresponds to better energy and carbon balance performances than simple incineration (this last with or without pre-treatment of residual waste). As far as energy and climate change issues are concerned, and according to the LCA results, an existing co-incineration plant should be preferred to a new incinerator (Appendix 5). However, the research has also highlighted that the efficiency of the production of RDF plays an important role

Energy (MJ) and climate change (CO_2) efficiencies for different waste treatment processes



	1A	1B	2A	2B
Incineration process	649	482,8	472,4	338,5
Heat from incineration	-42,4	-29,4	-32,1	-21,4
Electricity from inciner.	-204,4	-141,8	-154	-103
Recycling "other"	-36,3	-36,3	-52,9	-52,9
Recycling metals	-49,4	-49,4	-62,9	-62,9
Recycling glass	-17,8	-17,8	-20,4	-20,4
Recycling wood	-9	-9	-9,1	-9,1
Recycling paper	-109,6	-109,6	-153,5	-153,5
Recycling plastic	-36,9	-36,9	-52	-52
Treatment of biowaste	5,2	5,2	6	6
Collection	84,4	84,4	84,4	84,4



	1A	1B	2A	2B
Incineration process	607,3	367,9	436,3	253,6
Heat from incineration	-726,1	-504,2	-550,4	-366,6
Electricity from inciner.	-3457,5	-2399,9	-2606	-1743
Recycling other	-966,8	-966,8	-1411,3	-1411,3
Recycling metals	-753	-753	-959,4	-959,4
Recycling glass	-456,4	-456,4	-522,6	-522,6
Recycling wood	-796,5	-796,5	-804,4	-804,4
Recycling paper	-7356,4	-7356,4	-10299	-10299
Recycling plastic	-1575,4	-1575,4	-2219	-2219
Treatment of biowaste	-49,8	-49,8	-58,2	-58,2
Collection	1632,5	1632,5	1632,5	1632,5

Source: Gian Andrea Blengini, Politecnico di *Torino, Italy*

The LCA has also addressed advantages and drawbacks of residual waste pre-treatment prior to incineration. However, due to the fact that the panel of experts/stakeholders did not clearly specify the technology and the expected performances of MBT (mechanical biological treatment), the results and conclusions were less precise.

With these limitations in mind, the following conclusions from the LCA of alternative residual waste chains can be drawn. It will be possible to improve the LCA models when missing data and more precise assumptions will be made available. However these results can immediately be helpful to decision makers.

- Energy indicators highlighted that the residual waste chain, which includes pre-treatment plus incineration, is slightly less efficient (-5%) than direct incineration. However, this can be ascribed to landfill without energy recovery of the biowaste fraction out of MBT. A different scenario, which considered anaerobic digestion (AD) of biowaste out of MBT, was also considered and this last showed encouraging results, though preliminary. However, in case of AD, also logistic, technical and economic aspects should be considered in a future and more detailed LCA.

- The carbon balance has emphasised that the pre-treatment of the residual waste sensibly improves the climate change impacts in comparison to incineration without pre-treatment. However, also for this aspect the research should be refined. An important aspect is the dynamic carbon balance of landfilled biowaste after MBT and the actual efficiency of biogas capturing.

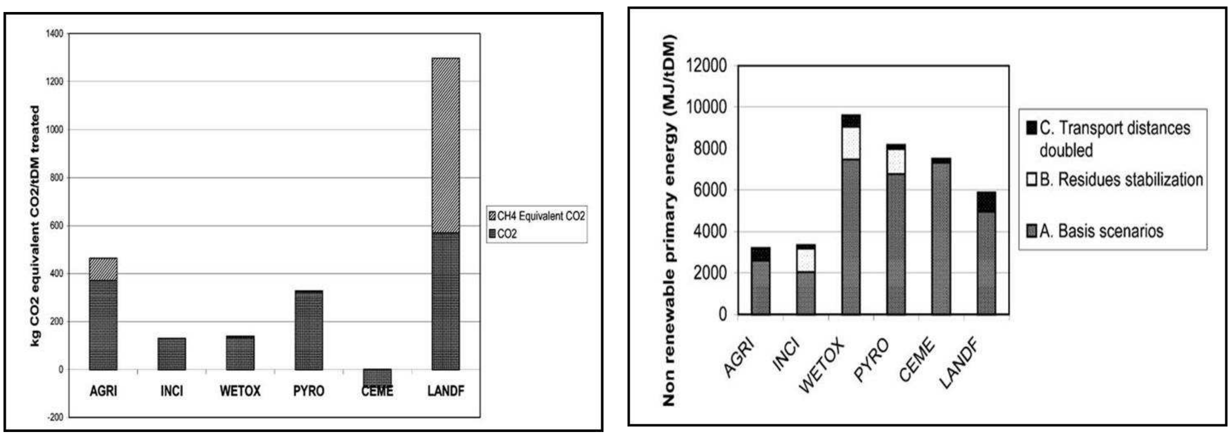
2.3 Energy and CO2 balance of sewage sludge treatment

RDC Environment presented on the energy and carbon balance of different sewage sludge treatments based on a study conducted by **G. Houillon**[10] in 2004**.** This study compares six wastewater sludge treatment scenarios applied to a 300,000 equivalent-inhabitant (eq. inh) wastewater treatment plant: agricultural spreading, fluidised bed incineration, wet oxidation, pyrolysis, incineration in cement kilns and landfill. The study focused on energy and emissions

[10] G. Houillon: BG Consulting Engineers (2004)

contributing to global warming over the whole treatment life cycle. As a result, avoided burdens[11] by co-products are very important in terms of energy consumption and pollutants' emissions. The energy balance suggests that incineration and agricultural spreading have the lowest non-renewable primary energy consumption. For global warming, incineration in cement kilns (CEME) has the best balance; landfill and agricultural spreading the worst.

CO2 and energy balance in sewage sludge treatments



Source: G. Houillon, BG Consulting Engineers (2004)

Therefore, it is difficult to conclude which is the optimal waste treatment process when it comes to energy and carbon balance on sewage sludge treatments. However, one of the main limitations of LCAs during sewage sludge treatments is the level and type of toxicity of sludge application on land related to organic micro pollutants (PAHs, dioxins –PCDD, Furan- PCDF) and /or heavy metals. Pollutants in sludge deriving mainly from human activities can prevent and/or heavy metals. Pollutants in sludge deriving mainly from human activities can prevent some treatment processes such as agricultural spreading.

[11] Burden: The total mass of a certain gaseous substance in the atmosphere. (Lenn) www.climatechange.ca.gov/glossary/letter_b.html

3. Sewage Sludge Treatment: Case studies from different European countries

Following the first day of presentations and discussions on 'waste co-processing' such as existing European and national Regulations, efficiencies in relation to CO_2 and energy balance by using different waste treatment processes, a series of brief case studies of sewage sludge treatments across Europe are presented below:

Case Study 1: Sewage Sludge management in Hungary

Hungary with its territory of 93.000 km2 and 10 million inhabitants is located in Central Europe, on the watershed of the river Danube. Since its accession in 2004, Hungary has to comply with the environmental requirements of the EU, incl. the Urban Wastewater Directive 91/271/EC. In Budapest there are two wastewater treatment plants in operation (North and South Pest), treating about 51% of the wastewaters of the city. With the completion of the third one, the Budapest Central Wastewater Treatment Plant (BCWWTP) the total treated wastewater quantity will rise to 95%.

Budapest Central Wastewater Treatment Plant

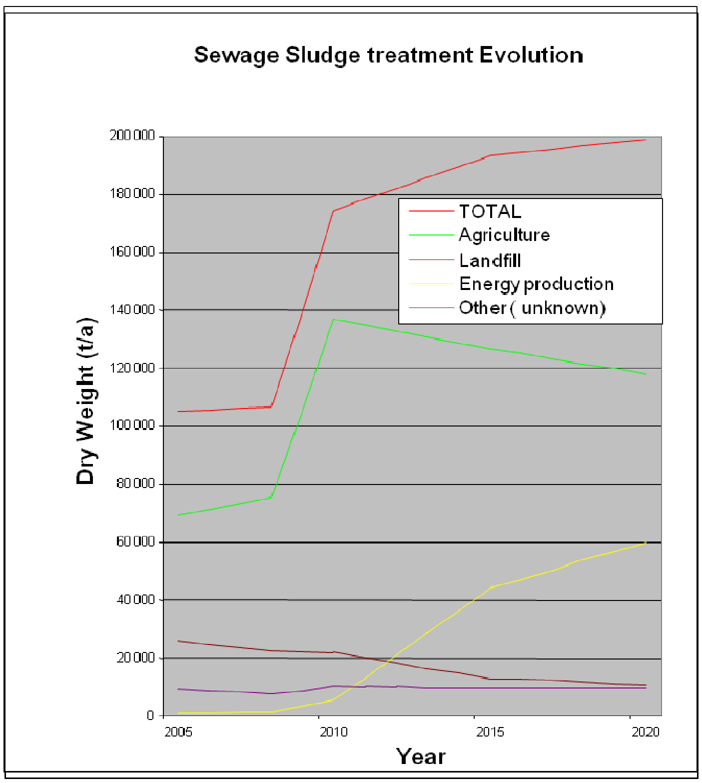
Source: City of Budapest

The investment cost of the BCWWTP is 249 million EUR, financed from Cohesion Fund sources. The maximum capacity of the plant was designed to 900.000 m3/day, with 525.000 m3 mechanical and 350.000 m3/day biological capacity. The construction is finished and the first year of the commissioning period started in the summer of 2009.

Originally the design of the BCWWTP included a project element for sludge disposal (composting plant – CMP) to receive 100.000 tons of sewage sludge /year. Due to civil protests in the 18th district of the city of Budapest as well as the request of the local authority to re-negotiate the agreement, the CMP was cancelled from the project and the EU recommended to amend the sludge strategy.

The sludge use prediction in Hungary for the period 2005-2020 shows that the total sludge quantity will slightly keep increasing. The use in agriculture will probably decrease with the time, while landfilling needs to be minimized by 2020. New objectives for sludge utilisation need a harmonised legal background and proper assessments.

Evolution of sewage sludge treatment in Budapest



Source: City of Mudapest (2010)

Several options were assessed for sludge treatment and disposal, such as:

- thermic utilization (use in cement factory and power plant, co-incineration at waste-to-energy plant, mono-incineration),

- use for recultivation purposes (Almásfüzitő red mud depositories, disposal at slag/fly-ash dumps)
- utilisation in agriculture (use of compost, production of energy plants, etc.)

However, constraints of sludge utilization are of different nature: civil protests (against implementation, transport, and operation), lack of environmental consciousness, contradiction between local interest and common goals, legal restrictions, problems with reception (capacity, infrastructure) and sustainability.

The actual mitigation plan for sludge handling and disposal in Budapest is based on a 10 year middle-term service contract following the commissioning period, the long-term solution of the sludge issue is under preparation (FS, CBA, EIA for the whole of Budapest wastewaters). The implementation of the final solution will make recourse of further EU funding.

Case Study 2: Sewage Sludge treatment in Spain and recommendations on the Sewage Sludge Directive

Generation of sewage sludge in Spain reaches approximately 1,000,000 tn/year of dry material. The main destination of sewage sludge is the application in agricultural soils, accounting approximately for 75% of the total. Only 15% is sent to landfill, 7% is directed for incineration and 2% is sent for other uses.

The future sewage sludge strategies in Europe, Spain and Andalusia, should take into consideration that:

• The use of sewage sludge for land application is the most sustainable and cost effective

• Landfill as the final destination of sludge is the least sustainable

• Energy recovery is presented as a highly recommended approach for large amounts of sewage sludge

According to EMACSA (Empresa Municipal de Aguas de Cordoba), the Municipal Water Company in Cordoba, responsible for the operation and treatment of water waste, there are several issues that need to be considered when looking at the future development of the sewage sludge Directive.

For sewage sludge operational waste managers and other specialists working in the field, their main interest is that:

• The legislation has to be complete, clear and viable, homogeneous for the whole of Europe but to consider geographical differences of the different European regions.

• The application is economically viable for existing facilities allowing investment, operation and maintenance and clearly defined design criteria, including design for future work, being associated with a system of consistent funding.

• The application period is reasonably long. Firstly, with regards to the costs of investment and secondly to avoid abrupt changes in regulations such as those experienced in the history of the draft directive.

• this policy carries trade regulations (not in use) of industrial and household products that alter the chemical and biological spills causing undesirable changes in the sludge of the sewage sludge treatment plants.

According to EMACSA, some of the conclusions of the new European directive will include:

- Most of the sewage sludge waste treatment plants should modify their installations to adapt the treatment for sewage pasteurisation.
- The use of sewage sludge as fertiliser on agricultural soils remains one of the best environmental and economical options, provided it poses no threat to the environment or to animal and human health.

Case Study 3: Sewage sludge composting in Odense, Denmark

The plant was inaugurated in 1999 as the country's biggest plant for composting sewage sludge, structure materials and straw. The consolidated area for composting including the storage site covers a total of 62,000 m^2, approx. 30,000 m^2 of which is used for the composting process (Appendix 6).

Sewage sludge composting plant in Odense

Source: City of Odence

At the plant, approx. 22.000 tons of biomass is composted on an annual basis: approx. 32.000 tons of garden and park waste, and approx. 3.000 tons of straw. After composting, approx. 21.000 tons of finished compost, so-called BioCompost, has been generated. The compost process takes 22 weeks and its final destinations include: courses (golf), gardens, and agricultural farms that grows not directly consumer's products.

Application of BioCompost

Trials in agriculture with different grades of compost showed that the compost is able to improve the soil structure. This structure-enhancing quality is particularly clear in soils with very high clay content. Moreover, the trials showed that the compost is able to improve the ability of the soil to retain nutrients and water.

Today the biggest users of BioCompost, is in agriculture. This is mainly because of the relatively simple processing of the finished compost required before supplying it to the farmer, and because in volume terms it is possible to dispose of a high proportion of the compost to farms.

In addition to the direct advantages, in terms of fertilisation and structure, that can be obtained by spreading the compost on farmland, there are also substantial advantages, in terms of handling and hygiene, from using compost rather than stabilised effluent sludge on farmland.

Control Requirements

The requirements for controlling effluent sewage sludge, structure materials, and the finished product are very detailed. The Plant Directorate, the county and the municipality monitor these elements.

It could be argued that this close control should be seen as a sign that the production contains a high risk. However, it may also be seen in the way that when so many authorities agree on controlling the same product, it is because they want to ensure that nothing is generated that could damage the soil.

Continuous Development

Operations and the whole process of composting at Odense North Environmental Centre undergo continuous development because of stricter statutory requirements and because of objectives to refine the product and improve the composting process even further. What may today be the most acceptable solution for treatment of sewage sludge, will not necessarily be tomorrow’s best alternative due to new technological advances, different soil conditions and other regulatory frameworks.

Case Study 4: Pre-processing and Co-processing of Sewage Sludge, Holcim

Europe makes up for more than 85 % of total sewage sludge use as highlighted by Holcim (2009) (Appendix 7). The main sewage sludge users in co-processing processes in Europe are Switzerland, France, Italy and Germany.

Based on Holcim's Annual Technical Report, up to 5% of thermal energy is substituted by the use of dried sewage sludge in cement plants.

	Net calorific value (as fired)	Sulfur content (as fired)	Chlorine content (as fired)	H2O as fired	Volatile matter (as fired)	Ash content (as fired)	% of Total Thermal Energy
	[MJ/t, MJ/1000 Nm3]	[%]	[%]	[%]	[%]	[%]	[%]
Plant 1	11'554			8.11		44.12	5.25
Plant 2	9'700					44.4	3.87
Plant 3	10'300	1.06	0.08	7.91	47.68	45.19	5.02
Plant 4	8'000	0.68	0.04	5.85	48.42	48.5	4.15

Source: HOLCIM Annual Technical Report

Cement plants could be an alternative to treat sewage sludge, but it faces several problems when recovering it.

Main problems when using sewages in cement plants include:

- The phosphates, rather than the potential effects against the environment it affects negatively the quality of the future cement. Currently several methods to extract P2O5, and use it in the fertiliser industry are being studied.
- The mercury content: To emit it to the atmosphere as particles is extremely pollutant.
- The moisture content: to dry the sewages is expensive. To solve it, it is advised to dehydrate it inside the depuration plants. It can be done by substituent the band-filter for press-filter or dry-thermo systems

However these options (substituent the band-filter for press-filter) are rejected by the depuration plants experts, for several reasons, such as economic or operational capacity requirements.

The main conclusion from this case study is that up to 5% of thermal energy is substituted by the use of dried sewage sludge in cement plants however there are some limitations that need to be taken into consideration (HOLCIM Annual Technical Report)

4. The residual fraction of municipal solid waste: Case studies from different European countries

When co-incinerating waste in a cement kiln, the requirements of existing European and national regulations have to be considered and requirements of the Waste Incineration Directive (Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste, WID) have to be met.

Member States have to ensure that industrial installations covered by the industrial activities specified in Annex I of the Directive are not in operation without a permit issued in accordance with this Directive. Relevant legal obligations are covered and '***Best Available Techniques***' (BAT)[12] are defined. Regarding BAT, associated monitoring, and developments in them, there is an exchange of information organised by the Commission between Member States, environmental and industrial non-governmental organisations concerned. The results of the information exchange are included in the 'Reference Documents on Best Available Techniques' (BREFs) which are published by the Commission[13]. Important issues for the implementation of IPPC in the cement industry is the reduction of emissions to air; efficient energy and raw material usage; the minimisation, recovery and recycling of process losses/waste; as well as effective environmental and energy management systems.

The cement industry is an energy-intensive industry. Various conventional fossil and waste fuels can be used to provide the thermal energy demand required for the process. Basically, characteristics of the clinker burning process itself allow for the use of wastes as raw materials and/or as fuels. The European cement industry recovers a substantial amount of waste-derived fuels, which replace fossil fuels up to a level of more than 80 % in some plants. A wide range of

---

[12] http://eippcb.jrc.es/reference/
[13] http://eippcb.jrc.es)

different types of wastes are used as raw materials and/or as fuels. Before considering the use of waste materials, different basic principles have to be considered, such as the appropriate selection of waste materials and an extensive analysing procedure of wastes and pretreatment.

Considerations and decisions have to be based on the clinker production process and the operational 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 European and national regulations, e.g. the Waste Incineration Directive (WID). Volumes and categories of wastes have to be considered as well as physical and chemical compositions, characteristics and pollutants. As a basic rule, wastes accepted as fuels and/or raw materials must give the following added value to the cement kiln: a) calorific value from waste material, b) material value from waste material. The calorific values of the waste fuels which are used in the process are very important quality requirements necessary to receive an improvement in energy efficiency and a positive input to the thermal process that supports calcination.

Best available techniques (BAT) for the cement industry using wastes as raw materials and/or fuels regarding energy consumption include: the use of waste including waste quality control, waste feeding into the kiln, and safety management for the use of hazardous materials.

Case study 5: Residual Fraction of MSW, usage of Stabilat® in Lägerdorf cement plant, Germany

Landfilling of untreated municipal solid waste is no longer permitted in Germany (TASi, 2005). The Holcim (Deutschland) AG is co-processing a residual fraction of the municipal waste treated by the preparation plant in Osnabrück. The so called "Herhof Drystabilat – Process" is a bio-mechanical waste treatment process. Target of the preparation plant is to produce a high quality alternative fuel and to guarantee a high recovery rate.

With the assistance of a computer-operated biological dry-process and a subsequent fully automated separation system the municipal waste can be separated in different fractions:

- Stabilat®: alternative fuel e.g. for the cement industry

- Inert material: e.g. utilization in road construction
- Ferrous and non- ferrous metals
- Batteries
- Process water: used as cooling water

Around 75 percent of the 40.000 t alternative fuels produced per year in Osnabrück are co-processed in the Lägerdorf cement plant. Approximately 87% of the preparation plant's MSW input is diverted from landfill, 13% can be recycled (i.e. road construction).

Exceedance of chlorine, cadmium and mercury limits were a challenge especially during the trials in 2006. Process and machinery optimization has solved the problem. Today the alternative fuel produced in Osnabrück complies almost always with the strict RDF-Specification of the Lägerdorf plant.

Figure 1: Stabilat - Softpellets

Case Study 6: ECOREC, rest fraction of MSW in Sofia, Bulgaria

Ecorec provides waste management services to Eastern European Countries focusing on waste treatment, energy recovery from waste and recovery via the cement industry. It offers a total capacity of 500,000 tonnes of waste for energy recovery.

They focus and re-process the 3 following waste streams:

- solid waste (packaging materials, industrial waste, sorted municipal waste other waste materials)
- sludge and oily waste
- waste tires (tires from vehicles , rubber waste from production, waste from tire recycling)

For the past 10 years the City of Sofia was facing serious waste management issues.

Source: Ecorec

A continuous increase in municipal waste generation (approx. 410 00 tonnes/year) and lack of landfill capacity led in 2 big crises in relation to municipal waste between 2005 & 2007. Under the pressure of EU Commission, an intermediate measure was undertaken in 2008. A public tender for sorting, transportation and recovery of solid municipal waste was announced. 3 manual sorting facilities for municipal waste provide sorted material to the company (Ecorec) for pre-treatment and co-processing in Holcim cement plant in Beli Izvor.

Ecorec invested more than 4 million Euros to ensure proper treatment and quality control of the sorted municipal waste. 3 years were required in order to commence collaboration with the Municipality of Sofia to improve their management waste services.

The main issue with the delivered sorted municipal waste that arrives at the Ecorec plant is the high level of moisture content. 120 000 tons sorted municipal waste will be accepted from Ecorec for pre-treatment and co-processing until the end of 2011.

Case Study 7: the rest fraction of municipal waste in the Province of Cordoba, Spain

The municipal waste management in the province of Cordoba is currently being managed a publicly owned company, EPREMASA[14], who serves a population of 450,000 inhabitants distributed in 74 municipalities. The waste generation is approximately 200,000 tonnes per year.

During the 1980's there were more that 150 illegal landfills but the scene changed rapidly following the creation of EPREMASA in 1992 and the implementation of a Master Plan, to improve the waste management in the province and provide an integrated management system for MSW. The most important objectives of the Plan were to ensure the effective treatment of waste and the closure of uncontrolled landfill sites as well as the concentration of all the provincial municipal waste in one 'landfill system' associated with the treatment of a composting plant. Due to the initial design of the composting plant to only treat 2/3 of the provincial waste volumes and lack of land in the installation process, EPREMESA had to look for alternative technologies to treat the **rest fraction** and **organic waste** generated in the Province. The new plant facility, in *Montalbán* that was built had the following features:

- composting tunnels: controlled environment consisting of a stainless steel frame and a semi-permeable membrane cover(Appendix 8)
- accelerate the fermentation process so as to obtain higher quality of compost
- Compost created in 25 days (in contrast with the old method: 90 days)
- maximize use of available space

The Montalbán Environmental plant is also equipped with a:

- leachate treatment plant
- landfill biogas recovery facility, converting methane form the fermentation of organic waste that has not been introduced into the composting process but instead has been deposited in landfill.

[14] Empresa Provincial de Residuos y Medio Ambiente SA

5. Conclusions

There is a growing need to change our way of thinking, our lifestyle, and more importantly our method of production and consumption. We need “a common sense revolution” as the EU Commissioner for Environment, Janez Potočnik states. In other words, we need to stop wasting resources and increase our reuse and recycling activities while becoming more eco-efficient.

Co-processing is the use of waste materials in resource intensive industrial processes such as cement, lime, steel, glasses and power generation, as defined by Jean-Pierre Degré, Vice President AR of Holcim Group Support Ltd.

“Co-processing” is an interesting concept that describes an economic activity which integrates both material and energy recovery.

We have now adopted a legal EU five-stage waste hierarchy and the question that remains unanswered is: “Which is the level of activities that combines both material and energy recovery?” The process of “biomethanisation-composting” can be considered as a combined operation of Co-processing as it allows the recovery of both biogas and fertiliser for soil improvement.

“Waste co-processing” at the level of cement production, must be assessed comparatively to other potential municipal waste treatments. (The debate can apply to other types of waste other than municipal waste, but our focus at this stage is mainly on “municipal waste”).

A first instrument to assess and compare the efficiency of such waste treatment technologies is the CO_2 or energy balance. There is still a lot to learn from those measurements, but we need to develop better standardization concerning the calculation methodology used. In any case, the conclusion with those reference criteria seems to be that highest efficiency is reached when following the EU five-stage waste hierarchy. In other words separate collection and recycling processes allow higher efficiencies than energy from waste type of technologies.

CO_2 and energy balance are key criteria when assessing different waste treatment processes.

However, there are many other environmental criteria that someone needs to take into account. A very effective instrument to assess and compare waste treatment processes is Life Cycle Assessment (LCA). LCA is an important tool that assesses the environmental impacts of a product or activity (a system of products) over its entire life cycle. However, there are some limitations when carrying out LCAs. In particular, levels of toxicity are not taken into account at a great extend.

With numerous LCAs already carried out, we can justify that Co-processing offers some very interesting results when taking into consideration the operation of some specific waste treatments and their waste flows.

In practice, there is a need to discuss the role of cement production and Co-processing in relation to two specific waste flows; the residual fraction of MSW and sewage sludge.

Sewage Sludge

With regards to sewage sludge, the question is different. The production of sewage sludge continuously increases but also the levels of contamination are increasing. It is clear that we first have to improve sewage sludge management at source: for example, aim to separate domestic used water from industrial used water, and to reduce the use of some chemical elements, like mercury, in industrial activities. A critical question remains though; At what levels do heavy metals cause harmful effects?'

With some technological advances, we can reduce the level of contamination to a certain extent that allows its use effectively on agricultural land.

But it's also true that some sewage sludge will remain highly contaminated and thus for this amount, Energy from Waste processes combined if possible with some material recovery are to be seriously considered.

One option in order to treat "contaminated sewage sludge" can be co-processing, with the advantage of combined energy and material recovery. This option requires some dewatering operation and so needs specific attention when calculating the energy balance. A very interesting point is the recovery of phosphorus– which seems technically feasible – and can take place before the co-processing of sewage sludge. Phosporus-rich products, such as calcium, magnesium, ammonium or aluminium can be reused either a substitute in the phosphate industry or as a new fertiliser.

We also have to consider the different criteria that need to be taken into account when we are dealing with sewage sludge waste deriving from large and medium cities rather than rural areas. In any case, the operation of the cement industry must be optimised. Member States when looking at the best available techniques for the waste treatment industries, have to follow concretely the IPPC Directive accordingly by referring to the 'Reference Documents on Best Available Techniques' (BREFs), published by the Commission in May 2010.

The cement industry is an energy intensive industry. Various conventional fossil and waste fuels can be used to provide the thermal energy demand required for the process. The future of the use of waste into the cement production industry will depend on various developments at a legal, economic, technical and cultural level.

With regards to legal aspects, a new IPPC directive will come into force at the end of 2011 and most likely also a revised directive concerning the spreading of sewage sludge on agricultural land.

Residual fraction of MSW.

With regards to the residual fraction of MSW, there is no clear definition, allowing many misinterpretations. A common terminology amongst member states should be agreed soon. The residual fraction of municipal waste should be seen as the remaining waste, after waste prevention or reuse activities have been applied to it and after it has been treated for recycling or composting.

As an example, if we consider the amount of 600 kg/inh/year of municipal waste produced, we should first look into reducing the waste at source by "less 100 kg" and preparing for re-use actions. Then, we should optimise the recycling-composting activities to reach a 65% target rate. Therefore, the “rest fraction” of the total amount of 600 kg of MSW would only be 175kg/inh/year (or 15%). With the remaining 175 kg, we can then look into the different options of co-processing or any other forms of waste treatment. This could be the beginning of a very interesting debate.

It is important for both Local Authorities and private sector companies to develop and encourage activities across all levels of the waste hierarchy, from waste prevention to material or energy recovery.

In terms of economic aspects, it is evident that more countries are now applying the polluter pays principle, introducing taxes on landfilling and incineration. This is a very important incentive to reach an ambitious recycling society within the next 5-10 years.

The public and private sector should work more closely to optimize co-processing by looking at capital investment in both sectors.

Furthermore, tighter criteria in construction procurement contracts could lead to a higher demand and efficiency in the production of more sustainable cement.

However, a final remark should be made on the cultural change. More and more, people and not just waste experts, are considering waste as a material and energy resource. This change in perception opens the way into a new world of behaviour, multi-stakeholder engagement as well as partnership at a local, national and international level.

Appendices

Appendix 1

The new EU recycling Targets:

		min recovery	min recycling	collection rate
Packaging	2008	60%	55%	
Cars	2015	95%	85%	100%
Electronics	2006	70%	50%	min 4 kg per inhabitant per year
Batteries	2011		50% to 75% (efficiency)	
	2012			25%
	2016			45%
Tyres	2006	0 landfill of tyres		
Biowaste diverted from landfills	2006	reduction to 75% of the 1995 level		
	2009	reduction to 50% of the 1995 level		
	2016	reduction to 35% of the 1995 level		
New targets (WFD)	2015	Separate collection: at least paper/metal/plastic/glass		
	2020	50% household waste and…		
	2020	70% construction and demolition waste		

Source: European Environment Agency

Appendix 2:

Overview Report: **Environmental, economic and social impacts of the use of sewage sludge on land**
(source: This report has been prepared by Milieu Ltd, WRc and RPA for the European Commission, DG Environment under Study Contract DG ENV.G.4/ETU/2008/0076r)

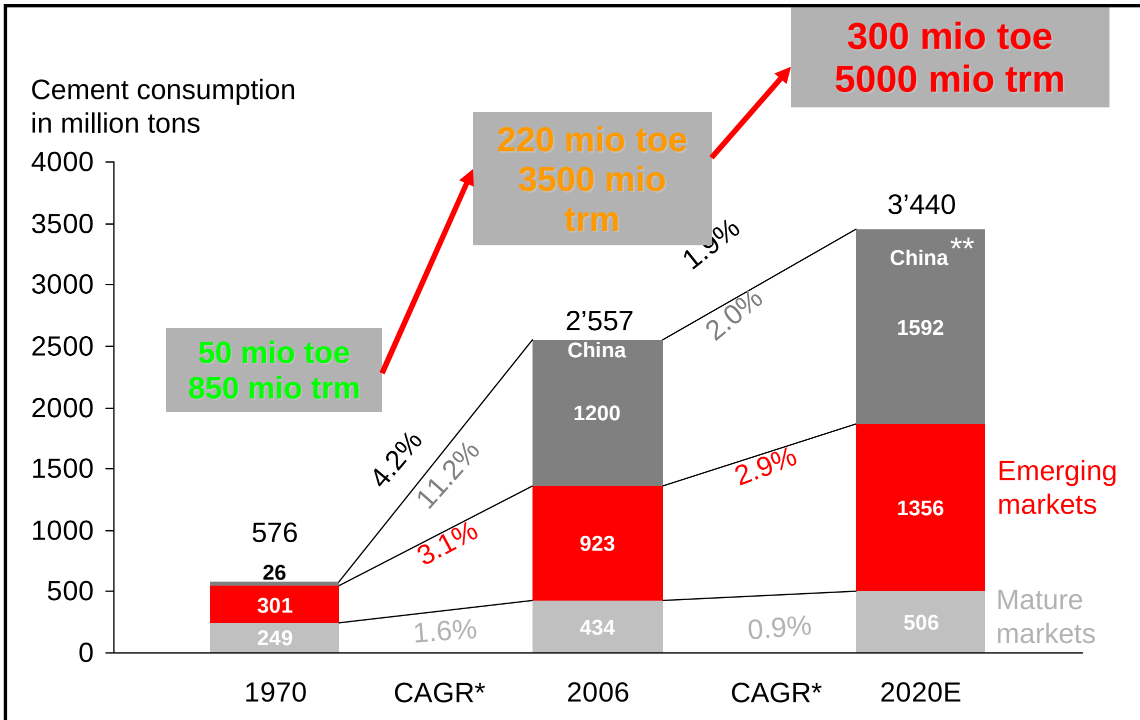
The following major trends are expected to influence the spreading of sludge on land:

- There will be a general phasing out of sludge being sent to landfill, due to EC restrictions on organic waste going to landfill as well as public disapproval: by 2010 the overall proportion of sludge going to landfill will be lower than currently reported, and it is estimated that by 2020 there will be no significant amounts of sludge going regularly to landfill in the EU27.
- Increased treatment of sludge before recycling to land through anaerobic digestion and other biological treatments, like composting. The use of raw sludge will no longer be acceptable.
- Potential increased restrictions on types of crops being allowed to receive treated sludge.
- Introduction of semi-voluntary and voluntary quality management programs such as the ones in place in England and Sweden to increase the safety of sludge use on food chain crops
- Increased attention to recovery of organic nutrients, including those in sludge.
- The main alternative to spreading sludge on land is likely to be incineration with energy recovery for sludge produced at sites where land suitable for recycling is unavailable. This will be the case in particular where population densities are high and public opposition, e.g. to odour problems, make it more difficult to recycle to land; it will be seen also where animal manures are over-abundant.

Developments related to climate change policy and renewable energy will also influence sludge management:

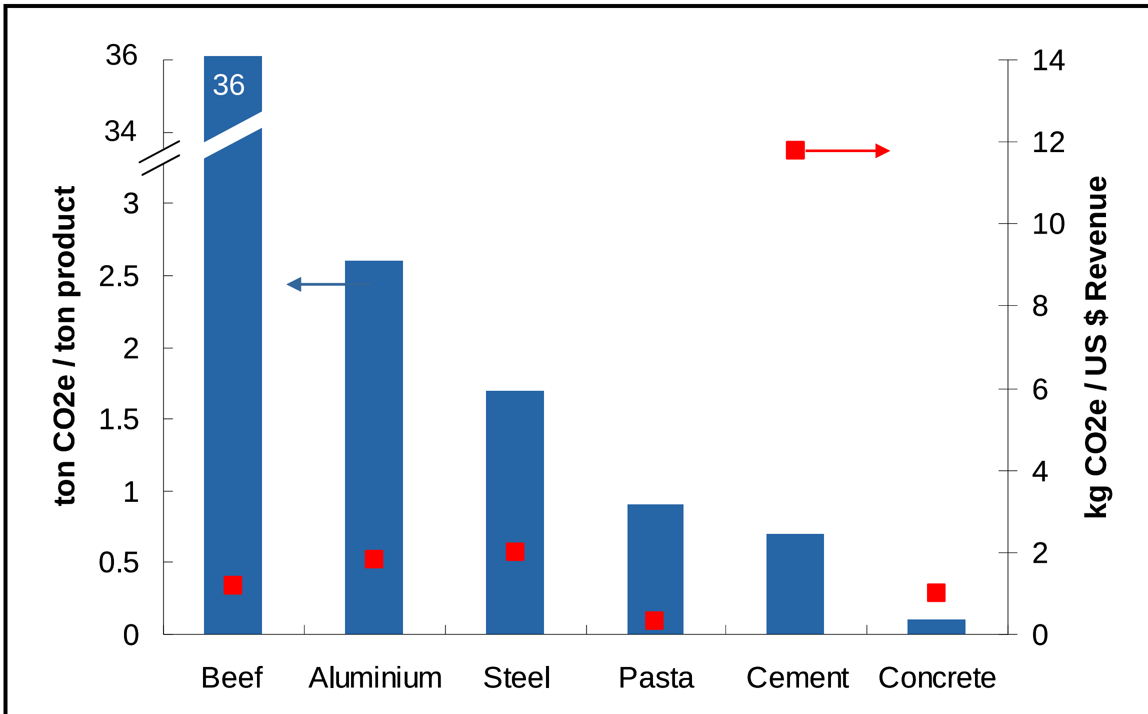
- Increased attention to climate change and mitigation of greenhouse gas emissions and thus recognised additional benefits of sludge applications to soils.
- There will be increased treatment of sludge with energy recovery through anaerobic digestion, incineration or other thermal treatment, with recycling of the ash. There may be increased production and utilisation of biogas from sewage sludge, as well as some production of alcohols and other fuels directly from sewage sludge using pyrolysis and gasification.
- Increased application of sludge to fuel crops such as miscanthus, hybrid poplars and other non-food energy crops.

Appendix 3: Cement production throughout the years

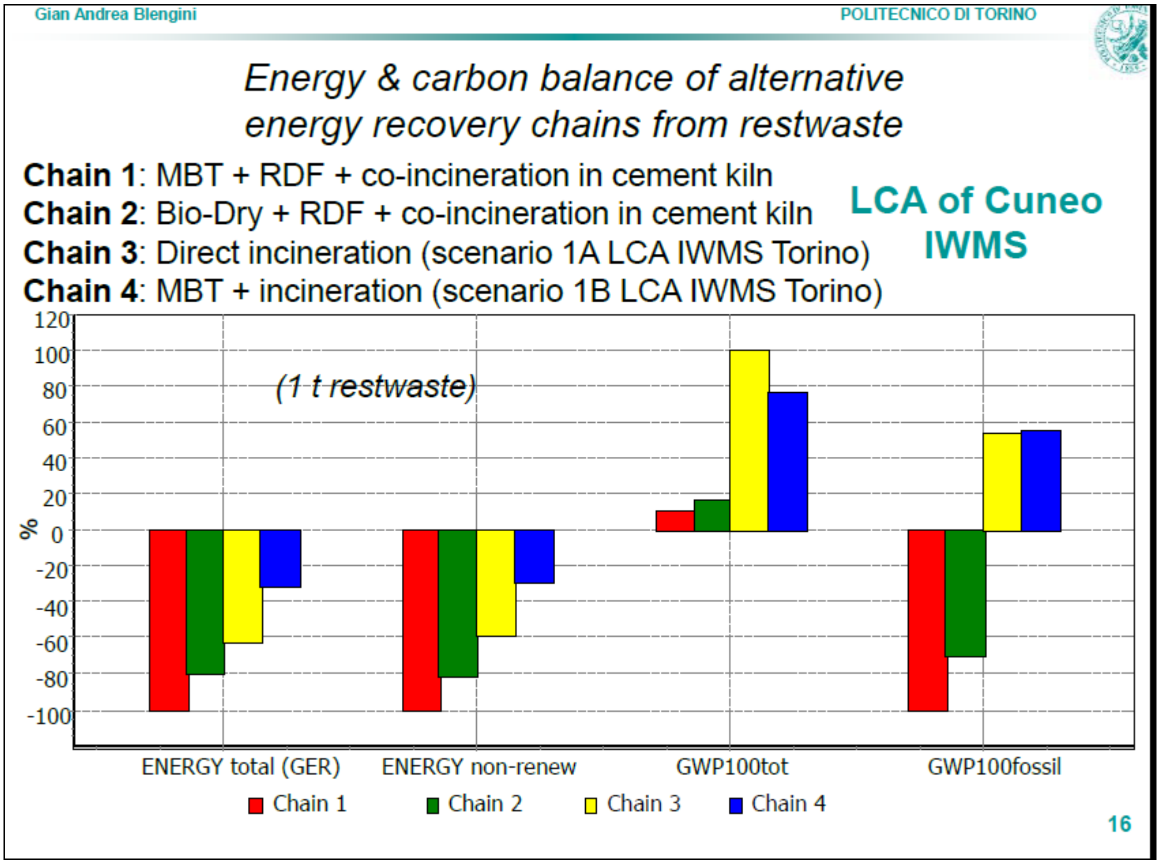


toe = tons of oil equivalent (42 GJ) ; trm = tons of raw material ; CAGR = Compound annual growth rate

Appendix 4: CO_2 intensity and financial exposure



Appendix 5: Energy & Carbon balance of alternative recovery chains from the rest fraction of municipal waste



Appendix 6:

The Composting Process in Odense,Denmark

The composting process is a process in which naturally occurring micro-organisms are used to decompose concentrated organic matter by the use of atmospheric oxygen, whereby the decomposition process is considerably accelerated. When an adequate volume of metabolizable matter is present and micro-organism requirements are met, so much energy is released in the composting process that the temperature can be increased to close to 70 degrees C.

The composting process is a biological decomposition process, which is conditional upon a number of conditions being met. This includes required optimisation of the following overall conditions, so as to obtain quick, effective composting at high temperature for sanitizing:

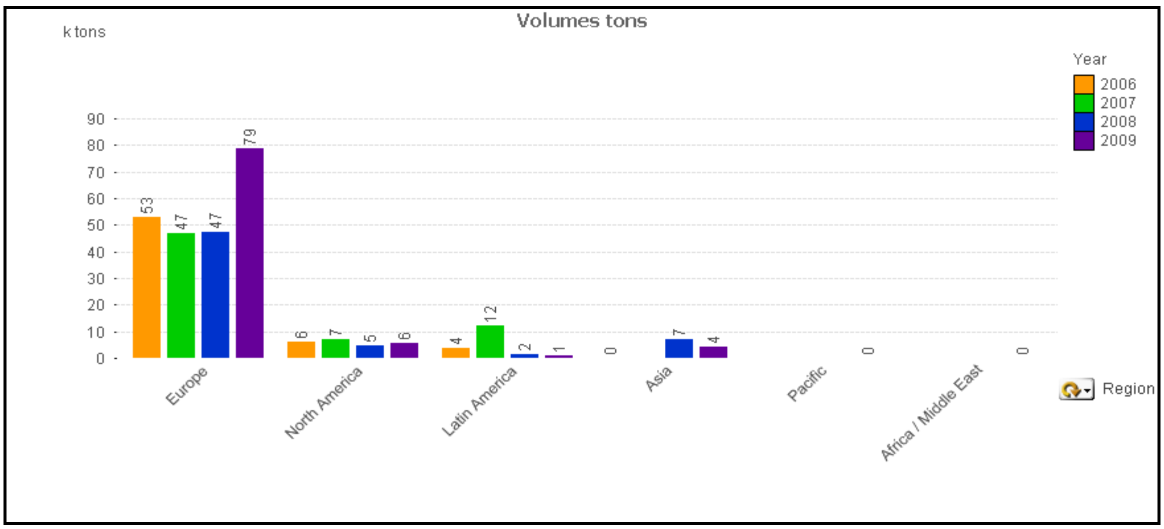
- High content of easily metabolizable carbon, preferably in the form of plant fibres

- An adequate volume of nutrient salts, such as N, P and K to nourish the bacteria growth during composting
- Water in adequate volumes for the bacteria to be able to divide throughout the process. The preferable initial content is 50 to 60 %
- A carbon/nitrogen ratio of between 20 and 30
- Turning of the rows to ensure that there is accessible oxygen inside the rows
- Covering of the rows for insulation and to counteract odours

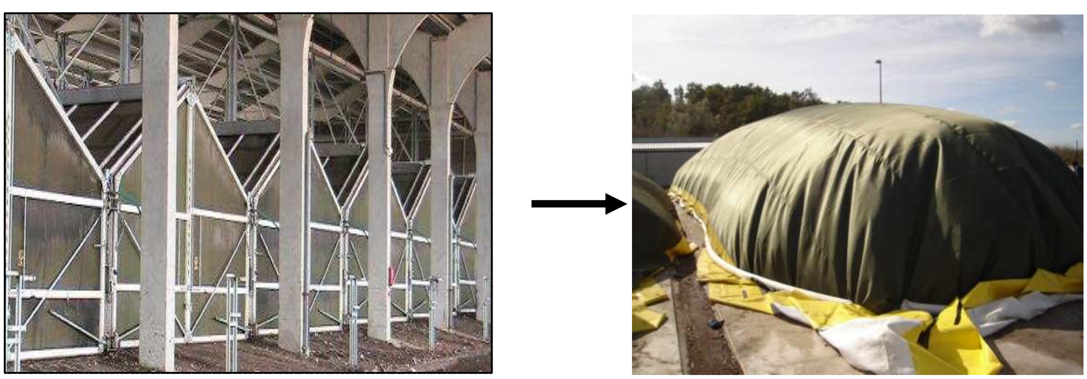
When these conditions are met, composting will accelerate to such an extent that the process has been completed after 8–10 weeks, followed by two weeks of cooling and twelve weeks of maturation on the storage site.

When maturation has been completed, the compost is typically sieved on a 5, 10, or 20 mm sieve. However, other options than those mentioned are available to meet customer wishes.

Appendix 7: HOLCIM sewage sludge co-processing operations across the world



Appendix 8:



Composting Plant facility in Montalban, Spain

Optimal recovery of material and energy resources: The cases of the rest fraction of municipal waste and sewage sludge

2nd Experts Seminar
16-17 June 2010 – Seville

PABELLÓN DE ITALIA, C/ Isaac Newton, s/n, 41092 Isla de la Cartuja, Sevilla

1. Context and objectives

After the first Seminar which took place in Turin on 9 December 2009, a new seminar is organised in the framework of the partnership between ACR+ and Holcim (see http://www.acrplus.org/default.aspx?page=545&editview=true). This Experts Seminar will be organised in collaboration with the Andalusian Government on 16-17 June 2010 in Seville and will focus on 2 specific waste flows: residual fraction of municipal waste and sewage sludge.

The seminar will gather a group of experts in order to discuss the issue of developing integrated approaches for specific waste flows through different waste treatment alternatives such as recycling, co-processing and energy recovery, with a view of reducing the consumption of material and energy resources and GHG emissions.

2. Programme

Wednesday, 16 June 2010

9:30 – 10:30 Introductory speeches

Introductory speeches: European waste management policy in relation to the specific question of material and energy resources

- Jean-Pierre Hannequart, ACR+
- Jean-Pierre Degré HOLCIM
- José Juan Diaz Trillo, Environmental Minister of Andalusian Government

10:30 – 11:00 coffee break

ACR+ Avenue d'Auderghem 63 B-1040 Brussels, Belgium T: + 32 2 234 65 00 F: + 32 2 234 65 01 info@acrplus.org

11:00 – 12:30 CO_2 , Energy and material balance of waste treatment alternatives: technical background and findings • ***Technology Innovation in the Cement Industry & the SET-Plan*** *Jose A. Moya Institute for Energy IE, Petten* • ***Energy and material balance of waste treatment alternatives*** Michael Ooms RDC (Belgium) • ***LCA of Integrated Waste Management Systems*** *Giovanni Andrea Blengini, DISPEA, Polytechnic of Torino CNR-IGAG (Italy)* • ***Analysis of recovery systems of the rest fraction in municipal waste*** Jose M. Oteiza, ISR (Spain)
12:30 – 13:30 Discussion time (facilitator: Jose M. Oteiza, ISR)
13:30 - 14:30 Transfer to Jerez de la Frontera (1h trip)
14:30 - 15:30 Lunch
15:30 - 17:00 Plant visit in Jerez de la Frontera
17:00 – 18:00 Transfer to Seville and Free evening

Thursday, 17 June 2010

9:30 – 12:00 Parallel Workshops (coffee break included)	
09:30 Workshop 1: Residual fraction of municipal waste ***Usage of Stabilat® in Lägerdorf cement plant*** *Morten Holpert, Holcim, Laegerdorf (Germany)* ***A pillar in the waste management of Sofia*** *Nikola Ovcharov, Ecorec (Bulgaria)* ***The ® BIOCUBI process for automate-biological treatment of waste*** *Luis Manuel Martinez Centeno (Tenocma)* ***The municipal rest fraction in Cordoba, Spain*** *Blas Molina, EPREMASA (Spain)* *Frauke Schorcht IPTS* **Interactive debate**	**09:30 Workshop 2: Sewage sludge** ***Sewage sludge management in Hungary –*** *Dorottya Tothne Nick, Budapest City Government (HU)* ***The rest fraction and the swage sludge cases*** *Arturo Gómez, EMACSA, (Spain)* *Jean-Pierre Degré HOLCIM (Belgium)* *Svend Byrial Poulsen - ODENSE* *Marc Molina i Rafa ACA (Spain) (pending)* **Interactive debate**
12:00 – 13:30 Reporting from the parallel sessions and debate	
13:30 – 14:00 Wrap-up and action plan	
14:00 – 15:00 Lunch and End of meeting	

IMPORTANT: PLEASE NOTE that all sessions of the seminar are interactive to allow participants to discuss their views and share their knowledge and experience with other attendees.

ACR+ Avenue d'Auderghem 63 B-1040 Brussels, Belgium T: + 32 2 234 65 00 F: + 32 2 234 65 01 info@acrplus.org