Market opportunities for use of alternative fuels in cement plants across the EU

Assessment of drivers and barriers for increased fossil fuel substitution in three EU member states: Greece, Poland and Germany

May 2016

List of contents

Executive summary

Situation:
European Commission (EC) aims to highlight technically feasible options and improve the potential of Waste-to-Energy operations in the EU. One of these options is co-processing of waste in the cement industry. EC plans to publish a Communication on Waste-to-Energy later in 2016.

Why this study:
CEMBUREAU realizes that the benefits of co-processing are not widely understood. Therefore, co-processing is not always considered as a viable option in the design of policies and it might not be covered adequately in the EC Communication on Waste-to-Energy.
This study was performed for the purpose of increasing the understanding of co-processing waste in cement plants as an waste-to-energy options. *The intention was not to provide recommendations for authorities and other stakeholders.*

Approach:
In order to account for the differences between EU member states, three case studies were carried out as a display of different levels of maturity in terms of waste management and co-processing rates. The case studies were for Greece, Poland and Germany. The focus is on the following three elements: (a) the overall potential, (b) the benefits and (c) barriers and drivers of co-processing waste in cement plants.

Key findings

> This study showed that co-processing of waste in cement kilns is already being widely employed across the EU, but that **the potential for further uptake is still large.**

> **There is more than enough suitable waste for co-processing.** A mature waste infrastructure to collect, separate and process the waste is mandatory to increase the uptake of alternative fuels in the cement industry.

> The three case studies for Greece, Poland and Germany showed that **there are large differences between the member states** regarding the status and prospects of co-processing.

> **National governments play a key role** in setting the right conditions for co-processing. Although appropriate EC regulations about waste management are in place, the level of compliance varies considerably between member states. In Germany and Poland most conditions were met and substitution rates have been increasing steadily. In the Greek case, co-processing is limited due to political questions on waste management and also due to lower willingness to pay for more advanced waste treatment on the governmental and public side.

> Increased co-processing rates across member states can further contribute to overcoming challenges such as **climate change, waste management** and **fossil fuel depletion**, while utilizing principles of **circular economy**.

> There is no technical limitation at the cement plants to increase the share of alternative fuels from 36% now to 95% EU-wide. If this can be achieved it can save expenditures in additional waste to energy plants up to **15.6 billion Euro** and avoid emissions of **41 Mtonnes of CO_2 per year.**

> Next to fossil fuel substitution, up to **5% of primary raw material** in clinker can be replaced by mineral ashes contained in the waste derived fuel, saving primary raw materials and avoiding **1.4 Mtonnes of mineral ashes** that otherwise would have been landfilled.

> Increasing the rate of alternative fuel use will require investments for the cement industry. These costs can be covered by a gate fee. However, the **willingness and ability to pay** for advanced waste treatment varies per country, largely depending on the economic situation.

> **Market distortions** hamper the further uptake of alternative fuels in certain member states, such as inclusion/non-inclusion of carbon price for different energy recovery options and reconsideration of biomass subsidies in power generation.

Introduction

European Commission aims to highlight technically feasible options and improve the potential of Waste-to-Energy operations in the EU

> The Energy Union Package (1)[1], adopted in 2015, mandates the European Commission to adopt a Communication on Waste-To-Energy (WtE)[2] during the course of 2016 with the aim to:

- Explore **synergies between energy efficiency policies, resource efficiency policies, and the circular economy**

> To support the Communication, EC carried out a study with the following objectives:

- (a) to **analyze current use of waste streams** in the EU-28
- (b) to **assess available WtE technologies and possible innovations** for improving WtE operations

This study analyzes the opportunities of co-processing waste in cement kilns as a WtE-option

> Co-processing waste in cement kilns contributes to the solution of **three major problems the EU is facing currently**:

- **Abate climate change**

  Alternative fuels form one of the main levers for CO_2-reduction in the cement industry. According to IEA (2), alternative fuels can contribute 0.75 Gtonnes of CO_2 worldwide to GHG emissions reduction up to 2050.

- **Improved waste management**

  Co-processing waste can reduce the volume of waste that is landfilled and efficiently use the energy content of waste. It fits in the EU waste management hierarchy.

- **Achieve a circular economy**

  Minerals in waste are captured in the product of the cement plant and do not have to be landfilled as is often the case with waste incineration. Furthermore, as raw mineral materials are replaced, it is also a resource efficient option.

> CEMBUREAU realizes that the benefits of co-processing are not widely understood. Therefore, co-processing is not always considered as a viable option in the design of policies and it might not be covered adequately in the EC Communication on Waste-to-Energy.

> The study aims to increase this understanding by providing factual evidence on the barriers and drivers of co-processing waste in cement plants.

[1] *List of references can be found in Annex A*
[2] *Annex B contains a list of all used abbreviations*

Energy recovery and incineration are used if other options of waste treatment, higher-up in the waste hierarchy, are not possible or available, but are always preferred over landfilling

- The Communication on WtE is primarily concerned with best possible utilizations of waste streams that are non-preventable, non-reusable, non-recyclable (or where sufficient capacities do not exist)
  - The three main WtE options in the EU are co-processing of waste in cement kilns, incineration with energy recovery (R1), and incineration without energy recovery (disposal; D10)
  - To advance energy and material recovery in both co-processing and incineration of waste, barriers, such as social, economical, technical, environmental, infrastructural and political, will have to be addressed.

Most preferred

EU Waste Management Hierarchy		
PREVENTION	1	Minimize the amount of produced waste
RE-USE	2	Re-use all waste to the greatest extent possible
RECYCLING	3	Save raw materials and energy through recycling
RECOVERY	4	Energy can be recovered from combustible waste
DISPOSAL	5	Only when other means or uses are depleted, waste is deposited to a landfill

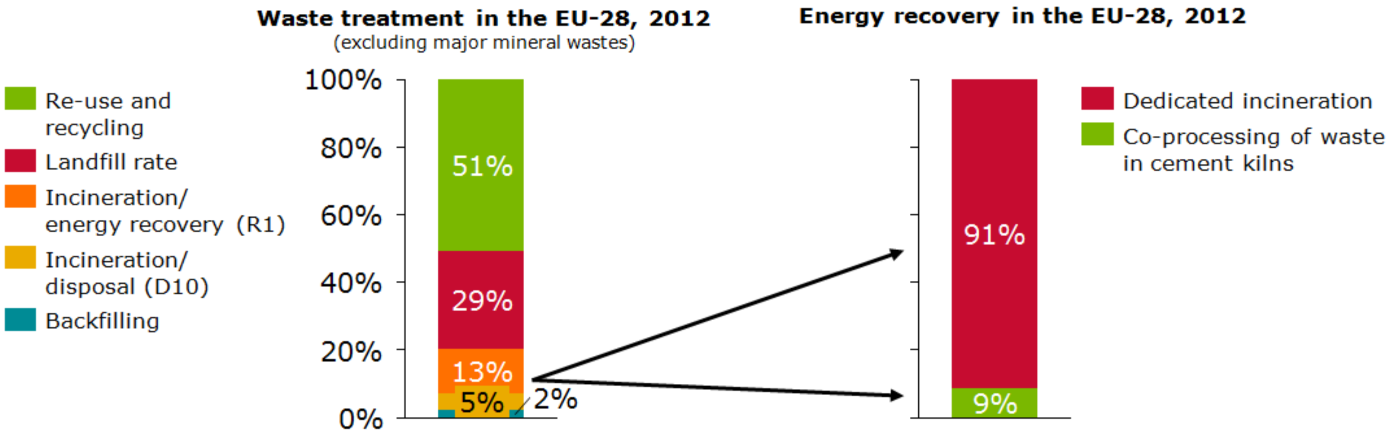
Least preferred

Co-processing of waste in cement kilns is one of the energy recovery options. It helps the cement industry lower its fossil fuel consumption and reduce its environmental impact

- Co-processing is the **simultaneous recovery of energy and the recycling of mineral resources** when alternative fuels are used to replace primary fossil fuels in cement/clinker kilns:
  - The traditional sources of energy in the making of cement clinker are **fossil fuels** like coal, lignite, petroleum coke, oil. In co-processing these are being substituted by **waste-derived fossil fuels** and **waste biomass,** together called alternative fuels.
- Due to the high temperatures and long residence time, the **destruction of such waste-derived fuels is very efficient and complete**.
- A difference compared to incineration is that the minerals in the waste fuel become part of the product (clinker):
  - The inorganic components of waste derived fuels ('ash') are broken down and incorporated into the clinker as minerals, thus replacing primary raw materials, and thereby **recycling** this fraction of the waste.
  - On top of this, many plants use specific mineral waste streams to replace primary raw materials.
  - About 5% of the materials used to manufacture the end product (clinker) can be substituted this way (3).

The cement industry co-processed almost 10 Mtonnes of waste in 2012. Still, the majority of energy recovery in the EU takes place in dedicated waste incinerators

- Eurostat reports that as of 2012, **29% of waste generated in the EU was landfilled** (exc. major mineral wastes) and **13% energy recovered** (4)
- Major part of energy recovery happened in **dedicated waste incinerators**, while the remaining energy recovery of waste was co-processed in cement kilns
- The European cement industry was responsible for **9% of all energy recovery** inside the EU in 2012 (3,4)
- In total, the EU cement industry co-processed more than 9.7 Mtonnes of waste in 2012, which was enough to **replace 36% of its energy consumption from fossil fuels** (3)
- Examples from Germany, Poland and other EU countries show that it is technologically and economically feasible to further increase this **substitution rate, possibly as high as 95%**



The study aims to provide factual evidence on the pros and cons of co-processing waste in cement plants

Three case studies were performed to collect evidence to answer the following three core questions:

Q1 **What are the barriers for higher fossil fuel substitution rates and who are the stakeholders influencing these?**

Q2 **What are the enabling conditions for increased use of alternative fuels in the sector?**

Q3 **Why is co-processing a good option for waste management and what can it contribute to the ambitions of climate and circular economy policies in the EU?**

The findings of this study are primarily meant to feed into the EC study on WtE-options. This is to ensure that co-processing of waste in cement kilns is rightly understood and will receive well-grounded coverage in the Communication.

Five types of barriers for increased use of alternative fuels in cement production are expected to be found in case studies

Expected barriers to fossil fuel use reduction	
Type of barrier	**What is affected?**
Infrastructural	- Availability of suitable waste - Cost of waste logistics - Landfill management (implementation of landfill ban, cost of landfilling) - Waste pretreatment facilities have to ensure consistency of delivered waste-derived fuels
Political/social	- Attitude of government and public towards co-processing - Incinerators (D10) and WtE plants (R1) are not regulated under EU ETS - Feed in Tariffs and other privileges for biomass based energy generation
Economical	- Investments on plant level: fossil fuel substitution requires large CAPEX investments for necessary facilities. The economics of waste-derived alternative fuels thus have to bring added value. - Societal willingness to pay: high landfill charges can stimulate alternative waste treatment methods. However, the society has to be economically able and willing to pay.
Technical	- The cement industry has to be technically ready to increase its use of waste-derived fuels
Environmental	- NO_x emission levels - Public perception of uncontrolled emissions from alternative fuel use

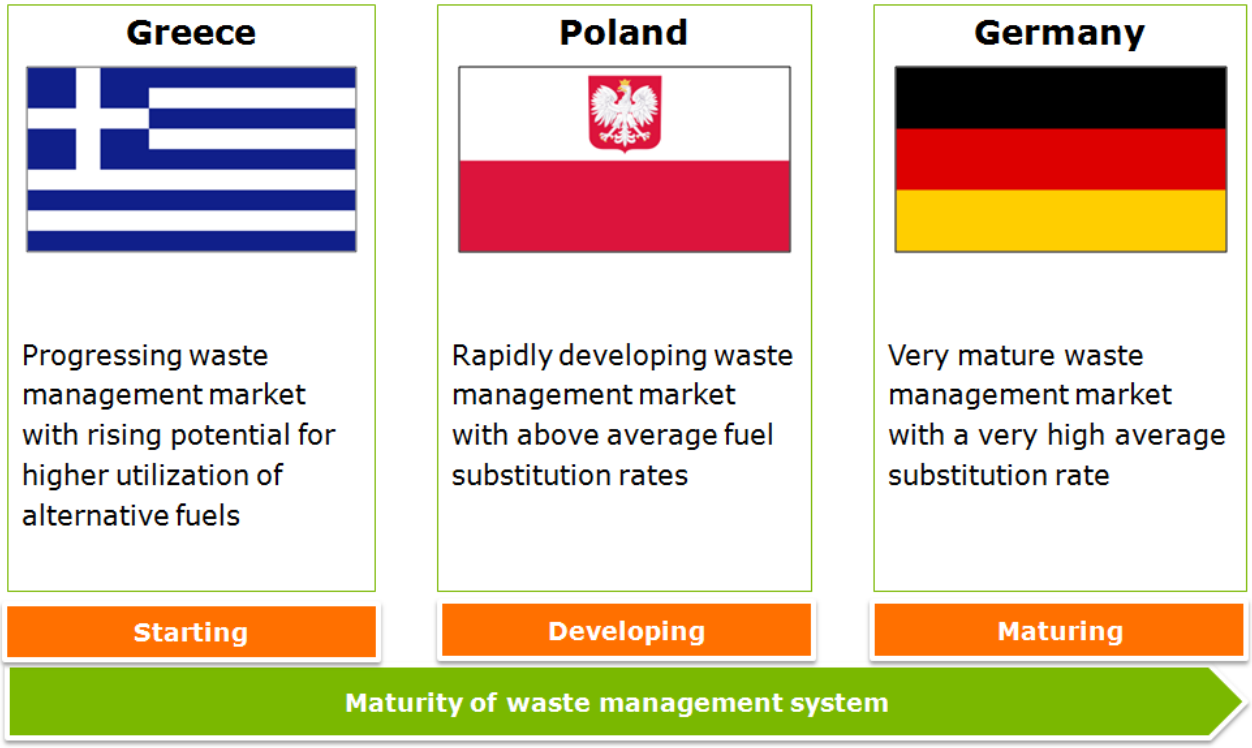
We quantify the benefits of increased alternative fuel use in four aspects. The methodology is explained below

Expected benefits from the use of alternative fuels	
Aspect	**Benefit and calculation methodology**
Fossil fuel savings	- Shown in **tonnes of avoided fossil fuels**, with coal used as a proxy (lower heating value 26 GJ/t)
Waste management benefits	- Shown as **tonnes of processed waste material**
CO_2 emissions mitigation	- According to the Cement CO_2 Protocol (5), GHG savings from the use of alternative fuels and raw materials are calculated as difference between gross (including AF) and net (excluding AF) use. Biomass emissions are considered a memo item and reported separately. The average carbon intensity of fossil fuels used in this study is derived from the logic above, standing at 93.5 $kgCO_2$/GJ. - **The total CO_2 savings (in Mtonnes)** are calculated using fossil fuel carbon intensity and total energy gain from waste-derived fuels (thus assuming their carbon neutrality). Avoided methane emissions from landfilling of waste are not accounted for.
Avoided incineration capacity and investments	- Shown in terms of **number of avoided average Waste to Energy plants and total avoided investment** - An average Waste to Energy plant is assumed to burn 150 ktonnes of waste annually - Range of investment is estimated to be between 0.55 to 1 M EUR/ktonne of annual capacity, average costs are estimated to be 0.78 M EUR/ktonne of annual capacity.

> Benefits in terms of the aspects above are shown in case studies and on EU level for current, expected, and highest possible rates of fossil fuel substitution.

Case studies

Three case studies were selected based on their maturity level in terms of waste management and utilization of waste-derived fuels



Case study 1: Greece

1. Cement industry

Greek cement industry has very high production rate per capita, and a large share of domestic clinker is being exported outside of EU. Production rate has been on the rise again since 2012 despite continuous decline in GDP.

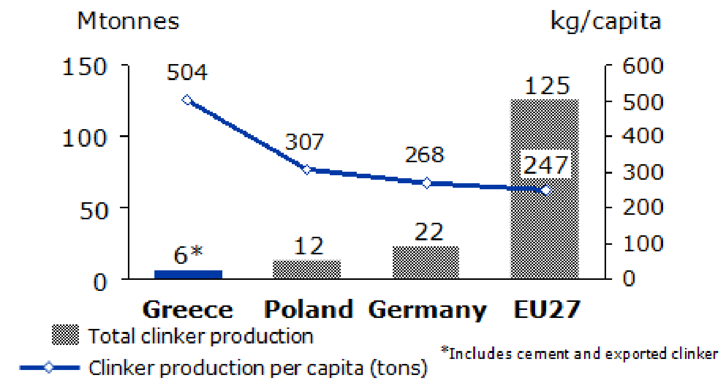
> Greek Titan Cement is the largest player in the local cement industry, and of Greek origin. It has 3 plants in Greece and also operates plants in Egypt, North America, Eastern and Southeastern Europe.

> LafargeHolcim (2 plants) and Italcementi (1 plant) are the other cement producers in Greece.

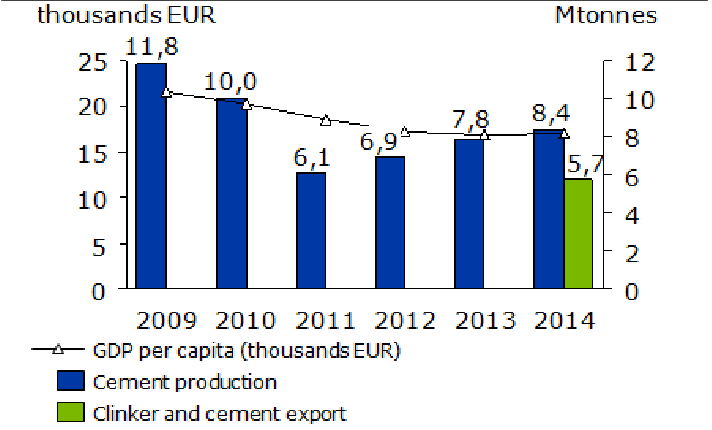
> The major part of Greek cement and clinker is being exported (68% in 2014); it is sent mainly to North Africa (1)

- As a result, Greece has a very high clinker production per capita (504 kg/capita in 2012 (2,3)
- After several years of decrease in production, the industry has been recovering well from a low in 2011, despite continuous shrinking of the country's GDP

Clinker production in 2012



Greek cement production including exported clinker and GDP



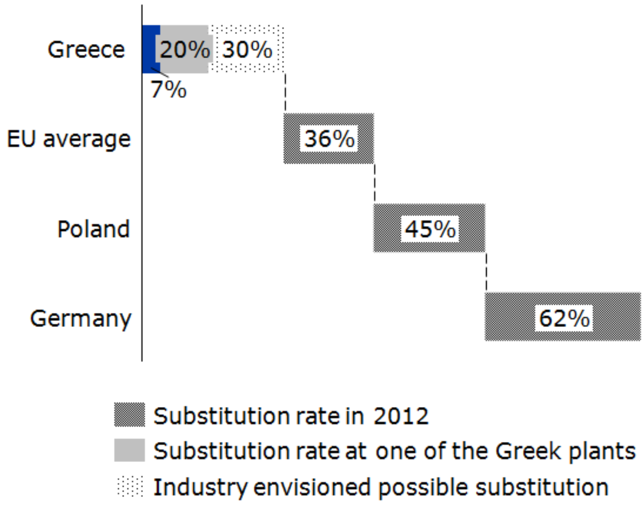
2. Use of waste-derived fuels

Current substitution rates are very low in Greece. However, if more suitable material is available and the permitting process is improved, the sector is ready to bring the substitution rate closer to EU average.

> As of 2012, substitution rates in Greece of waste-derived alternative fuels were **very low; on average between 6-7%** (compared to EU average 36%) (4), due to:
- **limited availability of suitable materials**
- **uncertain and lengthy permitting process for co-processing**

> However, the **investment barrier for increased use of waste-derived alternative fuels is already being lifted** for at least part of the Greek cement industry:
- Based on interview held with Greece cement industry expert one plant already reaches over 20% substitution
- the sector should be ready to increase its **substitution rate up 30% in short period of time**, if other barriers are mitigated. (4)

Alternative fuel substitution rate in 2012



3. Waste management policy

The government plans to significantly increase recycling rates and reduce landfilling. Energy recovery options have a secondary role in the country's waste management.

> **In 2015, Greece introduced its new National Waste Management Plan, aiming to:**

- Reduce generated waste per capita, prepare more than 50% of Municipal Solid Waste (MSW) for reuse and limit landfilling to maximum of 30% of total generated waste

> **Energy recovery only considered complementary treatment option after other recovery options have been exhausted**

- Production of Refuse-Derived Fuel (RDF) and Solid Recovered Fuel (SRF) is not considered to be an appropriate waste treatment option as those materials should be recycled according to the plan
- Utilization of waste-derived fossil fuels is considered as a process of high environmental impact
- There is no distinguishing between co-processing in cement kilns and other ways of energy recovery (8)

> **Implementation of the National Plan is however facing number of obstacles:**

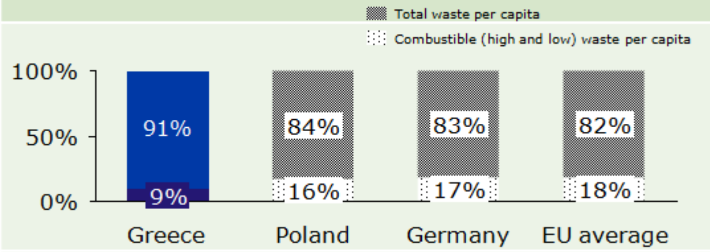
- Economical – Greece, currently facing an economic crisis, will struggle to deploy more advanced waste treatment methods than landfilling (such as energy recovery or recycling) as these are costly. On the other hand, co-processing could help alleviate part of this burden.
- Administrative - responsibilities for co-ordination of national and regional waste management are shared under different ministries, causing difficulties for actual implementation of the plan
- Logistical and infrastructural – Greece's geographical spread over many islands makes it hard to efficiently collect and process waste
- Attitude of local stakeholders - local residents often have a "not in my backyard attitude," which complicates construction on new sanitary landfills. In combination with insufficient landfill capacity, this results into illegal dumping of waste.

4.Waste management

Greece made progress in the last decade, promoting more recycling and reducing the number of illegal dump sites. However, its waste management is still underdeveloped and the majority of waste is still being landfilled or not maintained properly.

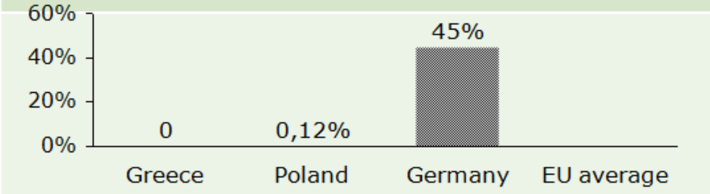
- As of 2012, **86% of total waste* generated was landfilled** (EU average 29%) and about **13% recycled** (EU average 51%) (2)
- Greece has a **high waste generation per capita** (6.5 tonnes per year) and below average share of combustible waste to total waste
- There are currently **no WtE plants** in Greece

Share of combustible waste to total waste (2012)



- There is insufficient capacity of sanitary landfills in the country
- **Landfill taxes are low** compared to EU average (40 EUR/t; with current gate fee in the 10 - 48.5 EUR/t range), however rather high in the context of southeast Europe (5-6 EUR/t) (5)

WtE capacity as share of combustible waste (2012)*

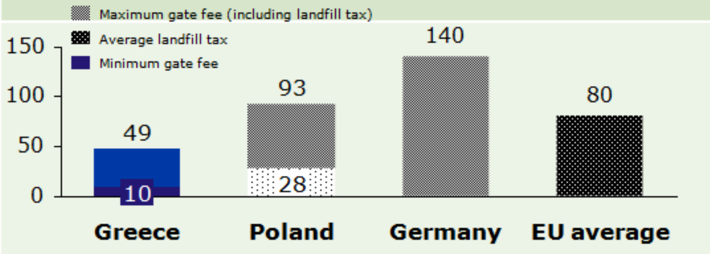


*not including hazardous waste incineration plants, capacity based on volume of processed waste

- The majority of the illegal dump sites have been closed and rehabilitated. However, the remaining sites still pertain a health and environmental hazard
- As of December 2014, 39 illegal landfills were still in operation and 206 additional sites were awaiting restoration
  - (The **EC fined Greece 10 M EUR** for infringement of the EU waste framework directive in the same year)

*total waste excluding major mineral wastes

Average landfill tax as of February 2015 (EUR/t)



5.Waste management and CO_2 reduction potential

The Greek cement industry could avoid 720 ktonnes of CO_2 annually at 30% substitution rate; an equivalent of approximately 293 ktonnes of coal

Waste treatment benefits

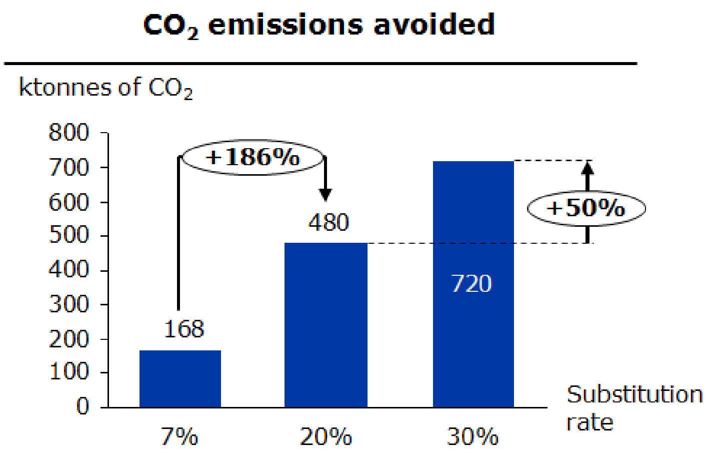
- In 2012, estimated **90 ktonnes of waste was co-processed** in Greece (7% substitution rate)
- Be the industry ready to lift itself up to 30% average substitution rate, this figure increases to 389 ktonnes annually, thus 5.7% of total combustible waste in Greece.

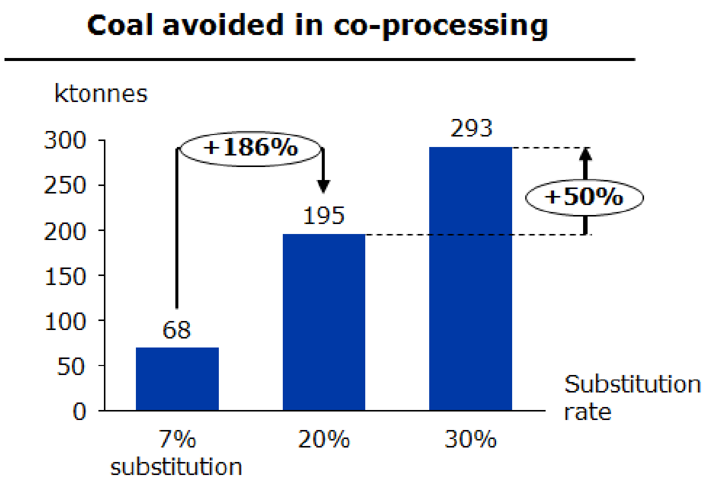
CO_2 reductions

- Use of waste-derived alternative fuels abated emission of estimated **168 ktonnes of CO_2** in 2012
- At a 30% substitution rate, the savings increase by 236% to **720 ktonnes of CO_2** annually

Energy production and approximated coal savings

- The cement industry generated **1.8 PJ of energy** from waste-derived fuels in 2012; an equivalent of **68 ktonnes coal**.
- This figure rises to 7.7 PJ of energy and 293 ktonnes of coal at a 30% substitution rate
- Present alternative fuel use avoids the need to build 1 average WtE plant, with 30% substitution investments into building 3 WtE plants can be avoided (or > 400 M EUR)





6. Barriers identified in Greece

Infrastructural and political are the main barriers to increased rate of fuel substitution in Greece. Despite this fact, cement industry plans to increase its use of waste-derived fuels.

Barriers to fossil fuel use reduction		
Type of barrier		**Influence**
Infrastructural	high	- Poor availability of suitable waste, not enough pretreatment facilities - Produced RDF not of suitable quality, currently being landfilled - High landfilling rate (86%), relatively low landfill tax (49 EUR/t), no landfill ban
Political/social	high	- Poor performance on EU waste management targets (landfilling) - Energy recovery not supported in national planning - Permitting process lengthy
Economical	medium	- Bad economic situation does not allow for expensive ways of waste treatment
Technical	low	- Investments have been made to increase share of alternative fuels - Industry is technically ready to increase the use of alternative fuels
Environmental (consequences)	medium	- Higher fossil fuel intensity of cement production

7. Opportunities identified in Greece

Reliable collection and waste treatment system along with a standardized licensing process will increase compliance with EU policies and make the cement industry more competitive

Driver	> Most Greek cement plants are technically ready to increase their use of waste-derived alternative fuels
What is needed?	> Reliable waste collection and treatment system, where majority of waste is recycled or prepared for use in cement kilns > A licensing process for use of waste-derived fuels which does not present an undue burden on the cement industry > Informing the society about the technicalities of co-processing and its difference to incineration
What is the opportunity?	**1. Closer compliance with EU waste and climate policies** > Less landfilled waste, both legal and illegal > Less fines for infringement of EU waste framework policy > Reduction of environmental impact of cement production **2. More competitive cement industry, as:** > Share of alternative fuels increases > Greek plants will have lower net carbon cost (closer to the benchmark) in the EU ETS > Production costs will lower as alternative fuels provide cost reductions compared to fossil fuels use.

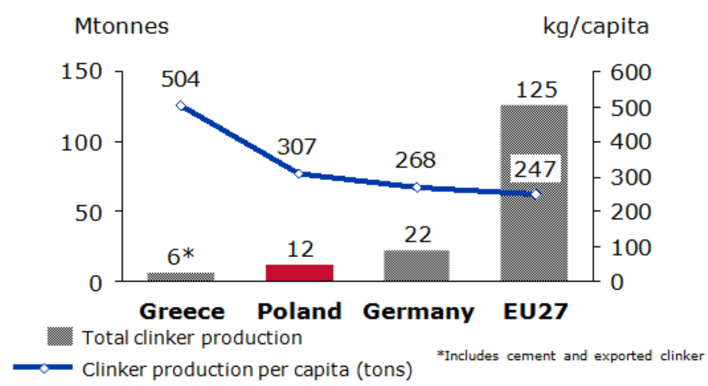
Case study 2: Poland

1. Cement industry in Poland

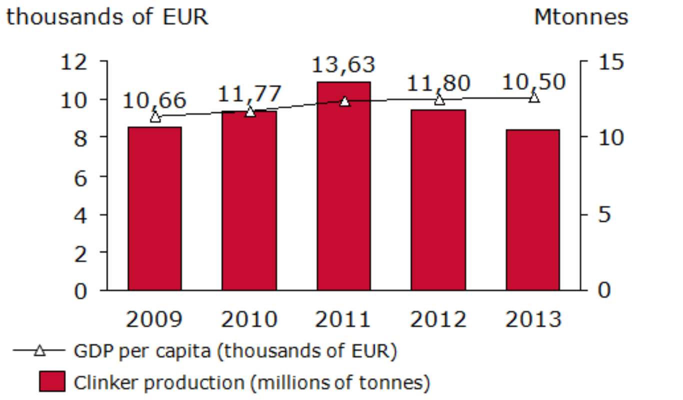
Polish cement industry has a slightly above average production rate per capita. Cement is used mainly internally; the past decade has seen a boom in construction and infrastructure development.

- Most players in the Polish cement sector are multinationals, these include: HeidelbergCement, LafargeHolcim, CEMEX, CRH, Buzzi Unicem and Miebach Group.
- Poland has 11 Portland cement plants:
  - 10 plants are fully integrated
  - one is a grinding plant
- Majority of cement is consumed domestically
- Clinker production peaked in 2011 at over 13.6 Mtonnes (Cement production was close to 19 Mtonnes) (1)

Clinker production in 2012



Polish cement production and GDP

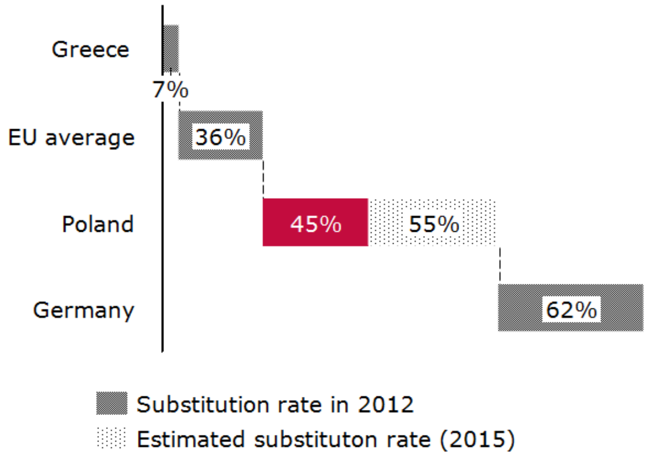


2. Cement industry in Poland

Fuel substitution rate developed quickly; 10 years ago this was around 15%. By 2016, some plants expect to achieve 80% substitution level.

- The fuel substitution rate in Poland was above EU average in 2012: 45% (compare to EU average 36%).
- It is estimated that as of 2015, the substitution level has risen to 50-55%. (1,2)
- Co-processing is encouraged by Polish government and viewed positively by the society
  - The cement industry is the largest consumer of processed waste as a fuel (1.2 Mtonnes/year)
  - Between 70% and 80% of AF used is of MSW origin, the other AF are used car tyres and sewage sludge
  - Consumption of RFD can grow to between 1.7 and up to 2 Mtonnes/year the coming years
  - Two cement plants already have substitution rates of over 80%

Alternative fuel substitution rate in 2012



3. Waste management policy in Poland

Poland plans to drastically increase waste processing capacity and recycling rates. Energy recovery plays a primary role in the country's waste plan.

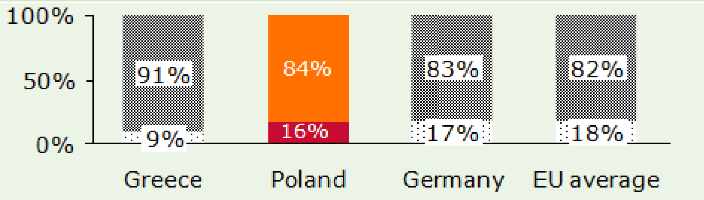
- **Poland uses a recent National Waste Management Plan (KPGO 2014) to formulate its Policy which aims to:**
  - Increase the number of MBT (Mechanical Biological Treatment) plants to aid recycling and waste processing
  - Reach thermal conversion of > 25% of mixed municipal waste in WtE facilities by 2020;
  - Reduce landfilling of MSW to less than 10% by 2025;
  - Invest heavily in the coming years, including construction and modernization of close to 100 composting and fermentation plants, 28 new MBT plants (with processing capacity of 1.2 Mtonnes), 27 sorting plants (with processing capacity of 1.8 Mtonnes), and 6 WtE plants. (4,5,6)
- **In the National Waste Management Plan, RDF/SRF is considered a product of recycling and MBT operations**
  - Production of RDF/SRF in MBTs, for specific use in cement production, WtE or district heating plants is seen as a key outlet product;
  - For use in the cement industry, the quality of RDF needs to improve. The cement industry has a need for high quality fuels, which are only partially being met at present;
  - Today the cement industry is the main RDF customer, even with WtE plants coming online the coming years it is expected that close to 2 Mtonnes of RDF will be used by the cement industry in the future;
  - Common waste collection standards and source separation in waste collection, overseen by the municipalities, is seen as a key challenge for high recycling rates (7)
- **The main question is if growth and investment in RDF production can keep pace with demand, especially with the advent of additional WtE capacity and RDF fired district heating plants**

4.Waste management

The EU is following the developing Polish waste sector critically. The majority of waste is being landfilled. Poland tries to balance waste related costs and targets.

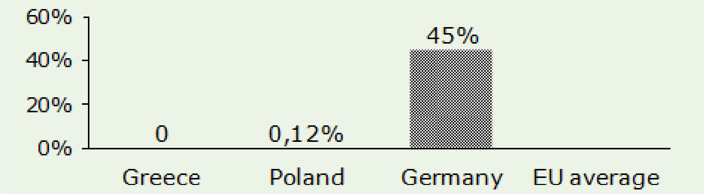
- As of 2012, **30% of total waste* generated was landfilled** (EU average 29%) and about **54% recycled** (EU average 51%)
- Poland has **one of the lowest rates of MSW generation per capita** (297 kg per year) and recovers most of its RDF from MSW recycling
- There are currently **6 WtE plants** being taken into operation; in 2012 WtE capacity was only 40 ktonnes/a

Share of combustible waste to total waste (2012)



- There is **sufficient capacity** of sanitary landfills in the country
- Since 2013 there is a **landfilling ban on separately collected combustible waste**
- **Landfill taxes are low at** 26,6 EUR/t (relative to EU average); current gate fees are around 50 EUR/t, with the upper end around **93 EUR/t** (8)

WtE capacity as share of combustible waste (2012)*

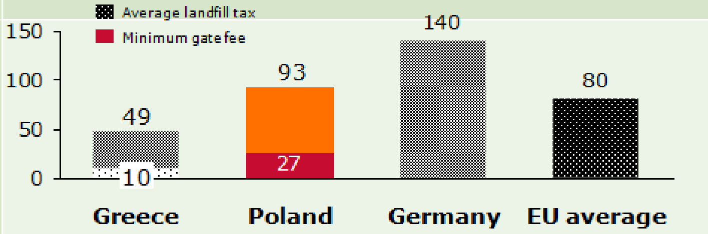


*not including hazardous waste incineration plants, capacity based on volume of processed waste

- In 2012, the EC requested the European Court of Justice to impose a fine of 67,314 EUR/day on Poland for **missing the deadline** for completing the transposition of the Waste Framework Directive
- The Government is seeking to balance increased recycling and advanced waste treatment costs; it is planned that the average amount of waste tax per capita should **not exceed 18 PLN/month** (about 4EUR/month)

*total waste excluding major mineral wastes

Average landfill tax as of February 2015 (EUR/t)



5.Waste management and CO_2 reduction potential

Polish cement industry will avoid emitting 1.8 Mtonnes of CO_2 annually at a 60% substitution rate and save 0.7 Mtonne of coal.

Waste treatment benefits

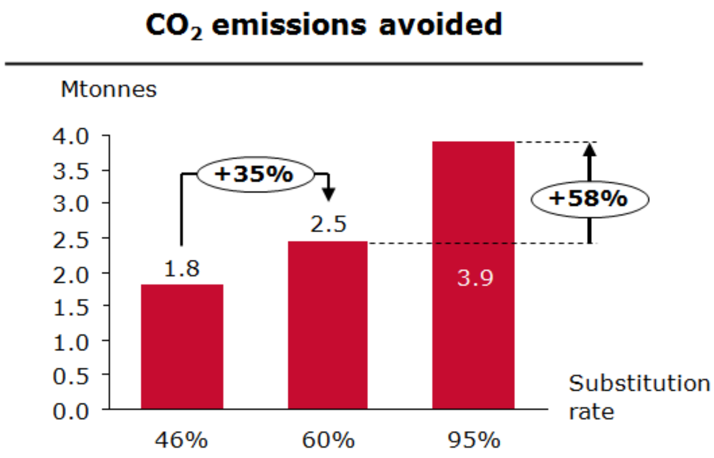
- In 2012, 1.1 Mtonnes of waste were co-processed in Poland (46% substitution rate); the main part being RDF.
- The cement industry will reach a substitution level **>** 60% by 2016, with an expected increase to 1.6 Mtonne annually.
- At this level, the industry will be absorbing roughly 1/3 of total expected future RDF processing capacity in Poland.

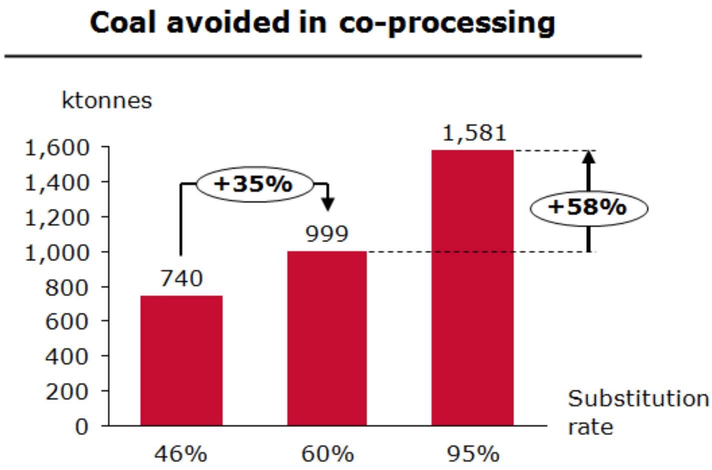
CO_2 reductions

- Use of waste-derived alternative fuels abated emission of 1.8 Mtonne of CO_2 in 2012
- At 60% substitution rate, the savings increase by 35% to 2.5 Mtonne of CO_2 annually

Energy production and approximated coal savings

- Polish cement industry replaced over 700 ktonnes of coal in 2012; this figure will rise to 999 ktonnes by 2016 when substitution levels go above 60%
- The 1.2 Mtonnes/a RDF processed in 2012 by the cement industry is equivalent to between 660 M EUR and 1.2 billion EUR in WtE plant expenditures
- By 2016, the additional 500 ktonnes of RDF leads to a saving of an additional expenditures of 275 M EUR and 500 M EUR in WtE plants.





6. Barriers identified in Poland

Limited source separation, gaps in pretreatment infrastructure and high investments are among the main barriers to more co-processing in cement production in Poland

Barriers to fossil fuel use reduction		
Type of barrier		**Influence**
Infrastructural	medium	- Produced RDF not always of suitable quality, due to limited source separation and lack of processing capacity - Only partial landfill ban, low landfill costs (50 EUR/t) - High level of capital investment is required to meet EU targets
Political/social	low	- General willingness to fulfill EU waste management targets - Slow implementation as a result of high investments required - Co-processing in clinker production is regarded as part of waste management practices
Economical	medium	- Low per capita GDP puts limits on waste management expenditure - Explicit cap set by government on waste related per capita expenditure
Technical	low	- The industry is ready to increase use of alternative fuels, it now needs high volumes and good quality Alternative Fuels to recover investments made
Environmental (consequences)	low	- Landfill share high, but declining - Necessary steps taken to move closer to EU climate and other waste and emissions related targets

7. Opportunities identified in Poland

Improvements in source separation and waste treatment systems, will help achieving compliance with EU policies and increase AF use in cement.

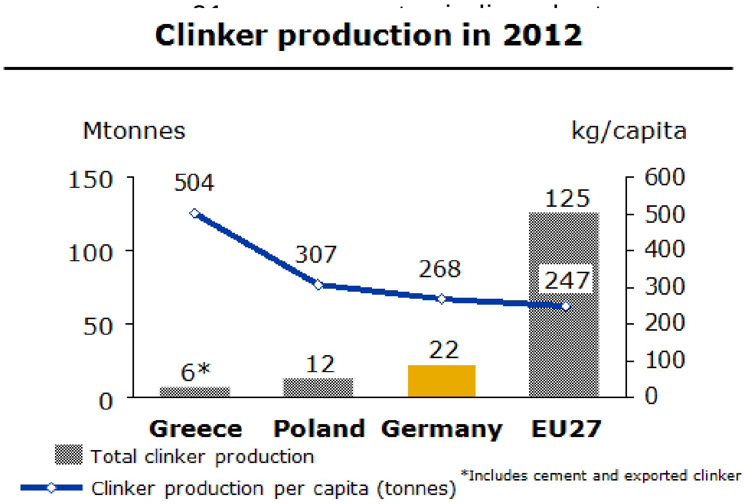
Driver	> Waste treatment capacity is growing, both in mechanical/mechanical biological and WtE terms > Most Polish cement plants are technically ready to increase their use of waste-derived alternative fuels > The cement industry offers a readily available, cost effective alternative to processing of waste in WtE plants
What is needed?	> Improved collection (source separation) and waste processing practices > Investments in collection and additional mechanical and mechanical biological waste processing capacities > Proper alignment of WtE and cement AF capacities, in order to reduce the risk of unnecessary investments
What is the opportunity?	**1. Closer compliance with EU waste and climate policies** > Less landfilling of waste, as envisioned in the Polish Waste Policy > Less fines for infringement of EU waste framework policy > Reduction of environmental impact of cement production **2. More sustainable cement industry** > With the increased use of alternative fuels in cement, the amount of incinerator ash going to landfill decreases > Polish plants will lower operational and carbon costs **3. Less burden on society** > By using more alternative fuels for cement production, less WtE investment is needed

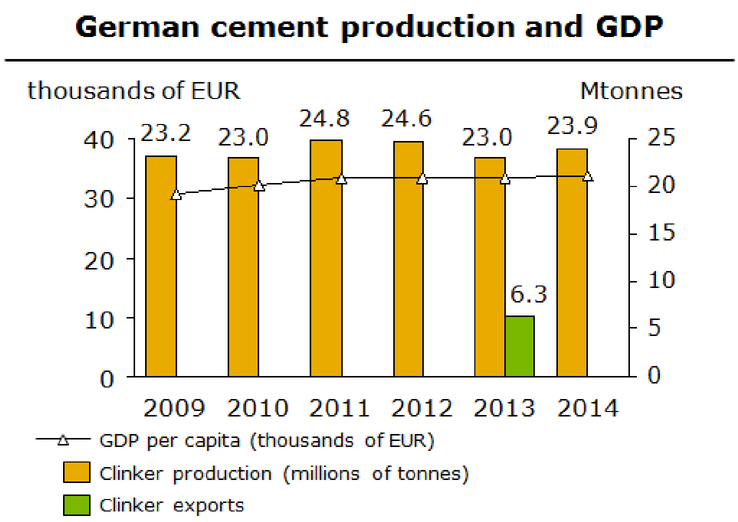
Case study 3: Germany

1. Cement industry in Germany

The German cement industry is mainly producing for the domestic market, is highly energy-efficient and automated, and uses a high level alternative fuels and alternative raw materials

- Germany had 22 companies producing cement in 2014
  - The market consists of a mix of global players (HeidelbergCement, LafargeHolcim, Buzzi Unicem, CRH, CEMEX) and a larger number of SMEs (like Seibel und Söhne, Miebach, Märker, Spenner, Rohrdorfer, etc.)
- In 2014, a total volume of 32.1 Mtonnes cement and 23.9 Mtonnes clinker were produced; roughly 20% of which was exported
- 55 plants were operational in 2014

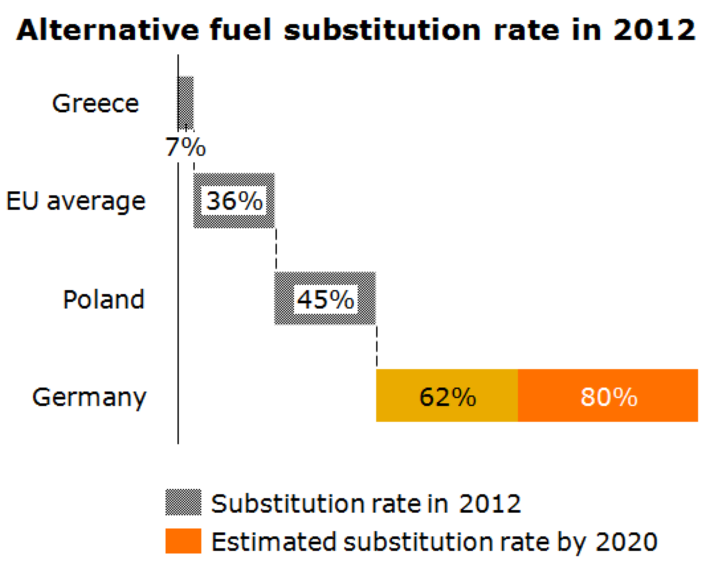




2. Cement industry in Germany

Since 1987, the German cement industry has increased its use of alternative fuels to a level surpassing conventional fuels while its environmental performance has also improved

- Current substitution rate in Germany by waste-derived alternative fuels is very high; reaching 62% substitution in 2012 and the potential to grow to a level of 80% by 2020:
  - Heavy investments have been made over the years: in permits, installations and abatement technology (emissions reduction and monitoring)
- Both government and society view co-processing in a neutral and sometimes critical manner
  - The federal government is appreciative of reduced GHG emissions as a result
  - Society is willing to pay for waste processing and sustainable solutions
- A waste industry with advanced waste processing plants can supply alternative fuels to a high standard
- Most AF originate from processing of commercial, industrial or 'separated' waste streams (packaging, etc.)



3. Waste management policy in Germany

Germany was amongst the first EU countries to enforce the landfilling directive; it has a well-functioning waste legislation and abides to most EU waste directives

- **In 2005 Germany abolished landfilling of MSW**
  - Landfilling of untreated biodegradable matter and of municipal solid waste containing organics ceased on 1 June 2005.
  - Today, MSW is mainly treated in MBTs or sorting plants; providing feedstock for further energy recovery in WtE plants or other plants undertaking energy recovery (like the cement industry) or the materials produced are recycled for reuse
  - Alternatively, MSW is brought to incinerators for end disposal
- **German policy execution has led to a waste sector with a high level of recycling, no landfilling (of MSW), and many options for energy recovery or incineration**
  - Almost 57% of municipal waste and 58% of production waste is recycled
  - The remainder is incinerated or used in energy recovery (like co-processing)
  - There already seems to be an excess capacity in WtE and incineration, which led to waste being imported for both incinerators and WtE plants.

But…

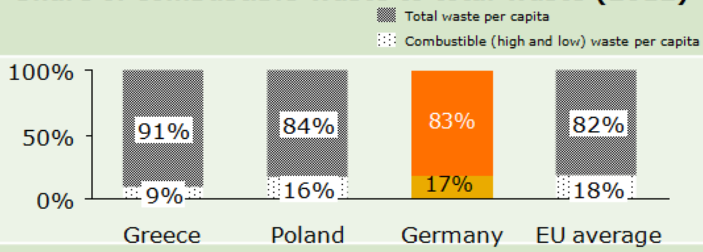
  - Incinerators and WtE plants are excluded from the EU-ETS, unlike cement plants, this is seen as a future disadvantage for the cement industry, due to expected shortages of emission rights
  - Biomass to Power and Biomass to Heat is privileged under the Renewable Energy Act (**EEG**) and Renewable Heating Act (**EEWärmeG**), which puts the cement industry at a disadvantage for using waste biomass based alternative fuels (sewage sludge, waste wood, etc.)

4.Waste management in Germany

Recycling rates in Germany are amongst the highest in Europe, incineration and WtE capacities can cover national requirements.

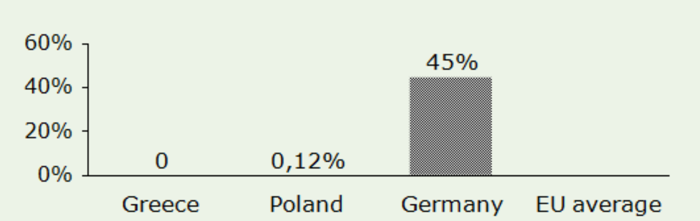
- As of 2005, **Municipal Solid Waste landfilling is banned.** Source separation (packaging waste recycling) is a success story.
- Germany has **a medium to high MSW generation per capita** (454 kg per year, 2012) and sends most of its unsorted MSW to one of its **60 incinerators**.
- As of 2012, **10% of total waste generated* was landfilled** (EU average 29%) and about **51% recycled** (EU average 51%)

Share of combustible waste to total waste (2012)



- In 2012, **36 WtE plants** were in use, running on processed waste fuel, with a capacity of 6.3 Mtonnes/a.
- There is **sufficient Mechanical Waste Processing and WtE capacity** in the country; this has led to large scale import of waste for recycling or energy recovery during the economic slowdown after 2009.
- The cement industry receives Alternative Fuels directly from industry (process waste) or from processing of specific waste streams.

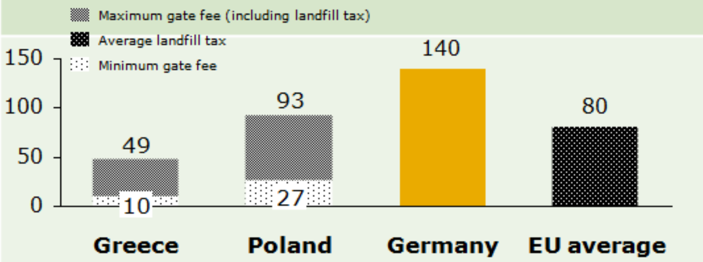
WtE capacity as share of combustible waste (2012)*



*not including hazardous waste incineration plants, capacity based on volume of processed waste

- Germany has amongst the **highest recycling** rates in the EU.
- Only treated (thermally or biologically), non-recoverable waste is admitted to landfills.

Average landfill tax as of February 2015 (EUR/t)



*total waste excluding major mineral wastes

5.Waste management and CO_2 reduction potential

Use of alternative fuels in cement has led to substantial reductions of CO_2 emissions, further increased use can bring additional reductions and substantial savings in WtE investments.

Waste treatment benefits

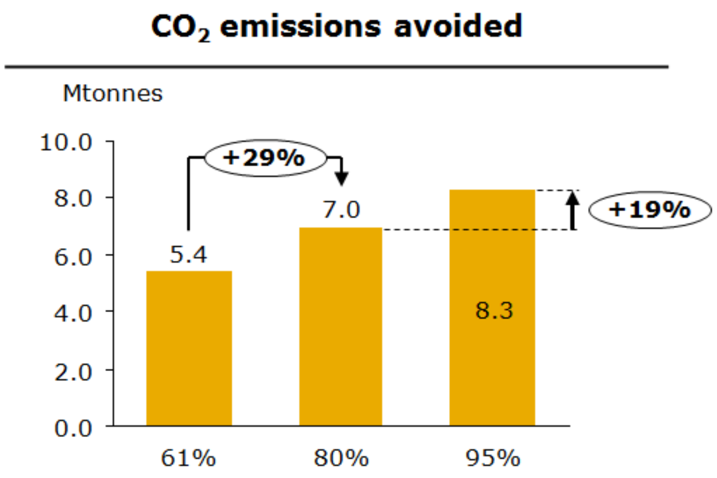
- In 2012, a total volume of 3.2 Mtonnes of AF were co-processed in Germany (61% substitution rate)
- If the cement industry substitution rate rises to 80%, annual AF waste co-processing volume can increase to around 4 Mtonnes; this is equal to roughly 60% of current German WtE capacity.

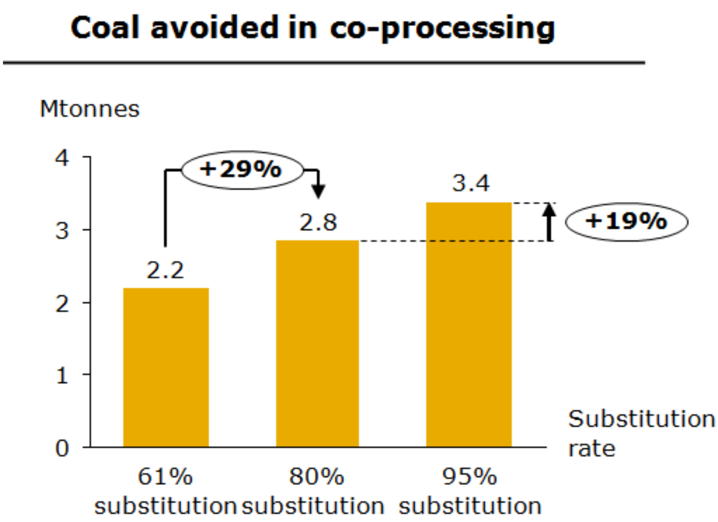
CO_2 reductions

- Use of waste-derived alternative fuels led to a reduction of emissions of 5.4 Mtonnes of CO_2 in 2012.
- At 80% substitution rate, the savings can potentially achieve an additional 1.6 Mtonnes of CO_2 emission reductions annually (assuming the same mix).

Energy production and approximated coal savings

- In 2012, the German cement industry replaced 57.7 PJ, or the equivalent of 2.2 Mtonnes coal, with AF fuels
- The 3.2 Mtonnes/a AF processed in 2012 by the cement industry is equivalent to between 1.7 and 3 billion EUR in WtE plant expenditure
- If AF use is increased to 80%, this figure rises to avoided expenditures of between and 2.2 and 4 billion EUR.





6. Barriers identified in Germany

Stringent legislation beyond EU BAT, competition from WtE plants and competition on biomass based waste streams

Barriers to fossil fuel use reduction		
Type of barrier		**Influence**
Infrastructural	Low	- Highly developed waste market with regional overcapacity - Competition with WtE plants - Costs of waste logistics
Political/social	Medium	- Federal government is positive on co-processing - Regional government and the public are neutral or even critical on co-processing
Economical	Low	- High per capita GDP - General willingness to carry costs for advanced waste management - Expected shortage of EU ETS certificates from 2020 onwards in the cement industry
Technical	Low	- Most plants are ready to achieve high substitution levels, additional investments are needed on fuel processing and emissions abatement
Environmental (consequences)	Medium	- Competition on Biomass based waste fuels might lead to slower reduction of GHG emissions - Additional 'on top' abatement measures, beyond EU legislation, introduced (NO_x) by local Government

7. Opportunities identified in Germany

Political focus on waste, massive investments and reliable collection, and treatment systems brought Germany to its present waste leadership position

Driver	> Well developed and reliable waste processing industry > Long term AF use experience > Economic incentives to use AF > Need to reduce GHG emissions under EU ETS
What is needed?	> Improvement of waste processing technology to make better fuels from lower quality waste streams > Balancing the capacities of WtE and the cement industry to avoid overcapacity > Achieve a level playing field between cement industry and WtE / Incinerators regarding GHG emissions from waste derived fuel > Achieve a level playing field between cement industry and privileged projects with regard to waste biomass
What is the opportunity?	**1. Improvement in waste pre-processing and expansion in its capacities leads to more jobs in the waste industry** **2. Co-processing and WtE capacity balancing leads to overall reduction in costs and investment burden on society** **3. Increased use of waste biomass in co-processing** > Further reduction of GHG emissions at industry level > Lowering overall costs to achieve national GHG reduction targets

Conclusions

This study investigates how and why co-processing could be supported in the WtE communication

Three case studies were performed to collect evidence to answer the following three core questions:

Q1 **What are the barriers for higher fossil fuel substitution rates and who are the stakeholders influencing these?**

Q2 **What are the enabling conditions for increased use of alternative fuels in the sector?**

Q3 **Why is co-processing a good option for waste management and what can it contribute to the ambitions of climate and circular economy policies in the EU?**

Q1

EC defines the overarching principles for waste management and various energy recovery options. Level of implementation however depends on national and local governments and is diverse across countries.

Influence on use of alternative fuels	
Stakeholders	**Influence**
European Commission	- Issues EU directives on Waste Management and Emissions Trading - Supports national government by providing various instruments, such as BAT / BREF
National government	- Implements national directives on waste management and treatment, pollution control, ensures compliance with EU directives and beyond, provides feed-in tariffs for green biomass based energy - Together with municipalities, puts price on waste (landfill bans, taxes or gate-fees)
Local government	- Issues permits for use of alternative fuels - Often directly responsible for implementation of national directives
Cement industry	- Has to be technologically ready, while replacement of fossils fuels has to bring economic benefits
Waste management industry	- Ensures availability and consistency of suitable pre-treated waste, which is crucial for co-processing
Waste incinerations and energy utilities	- Compete for available waste streams with co-processing
Public	- Public can oppose or support energy recovery operations - Often, incineration and co-processing are mistakenly taken as similar, leading to creation of misinformed opinions

Q1

Technical barriers for waste use in cement plants seems to be lifted in all three selected case studies. On the other hand, increased use of alternative fuels seems to be mostly slowed by infrastructural and political barriers.

Observed barriers from case studies			
Type of barrier	**Greece**	**Poland**	**Germany**
Infrastructural	- Poor availability of suitable waste - High landfilling rate (86%), relatively low landfill tax (49 EUR/t), no landfill ban	- Limited source separation and lack of processing capacity. - Only partial landfill ban, low landfill costs - High level of investment required	- Highly developed waste market, with regional overcapacity - Competition with WtE plants - Costs of waste logistics
Political/social	- Permitting process lengthy - Energy recovery not supported in national planning - "Not in my backyard"-attitude of locals	- General willingness to fulfill EU waste management targets - Slow implementation as a result of high investments required	- Co-processing supported by Federal government - Local Government and public have a neutral to critical attitude
Economical	- Bad economic situation does not allow for expansive ways of waste treatment	- Low per capita GDP - Waste treatment cost is capped (4 EUR/capita/month)	- High per capita GDP - Willingness to carry advanced waste management costs - Expected shortage of EU ETS certificates from 2020 onwards
Technical	- Over 20% fuel substitution in one cement plants - Investments have been made to increase share of alternative fuels	- The industry is ready to increase use of alternative fuels, it now needs high volumes and good quality Alternative Fuels to recover investments made	- Investments are needed on technically feasible fuel processing and emissions abatement
Environmental	- Poor performance on EU waste management targets (landfilling), - Higher carbon intensity of cement production	- Landfill share high but declining - Necessary steps taken to more closer to EU climate targets	- Biomass waste competition, reduced GHG reduction potential - Compliance required beyond EU regulations (e.g. lower NOx limits)

	Starting	Developing	Maturing

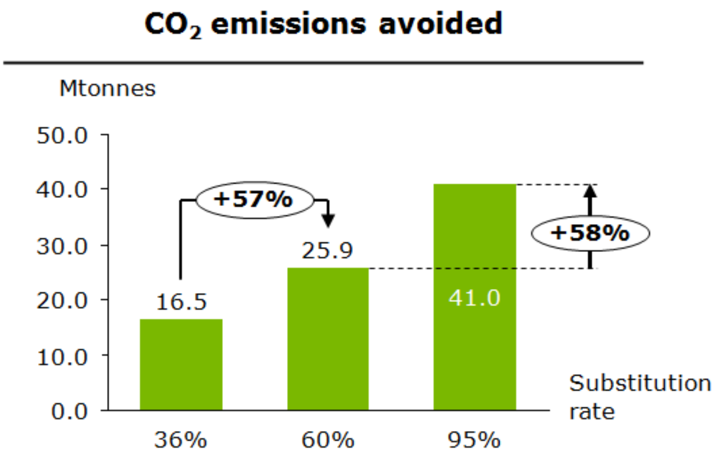
Maturity of waste management system →

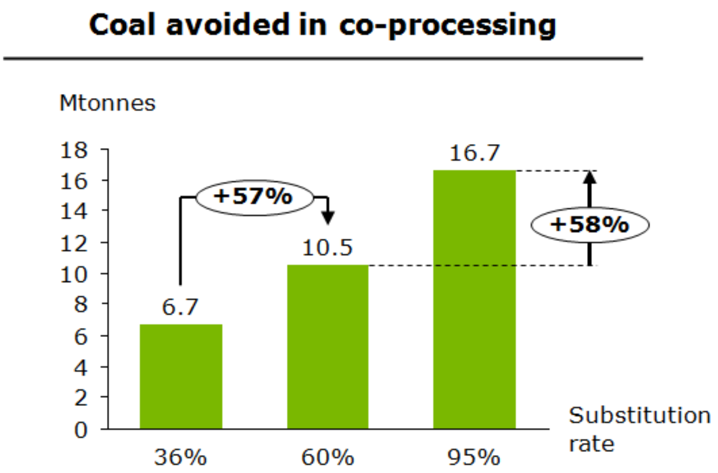
Q2 Meeting of the following conditions would facilitate higher uptake of waste-derived fuels in the cement industry and increase fossil fuel substitution

- Infrastructural
  - Developed waste pre-treatment industry, which can ensure reliable and consistent waste streams to the cement industry. It is essential, that the cement and pre-treatment industries work closely together to secure consistency of delivered waste.
- Economical
  - Full realization of the EU waste hierarchy, which disincentives landfilling of waste and prioritizes more advanced waste treatment methods. On the side of the society, there has to be willingness to pay for proper waste utilization. Additionally, a level playing field should be created by addressing market distortions such as inclusion/non-inclusion of carbon price for different energy recovery options and reconsideration of biomass subsidies in power generation.
- Technical
  - Long-term commitment of the cement industry to co-process waste.
- Political/social
  - Good understanding of the technicalities of co-processing amongst the legislators with preferably long-term vision of waste management in the country. Public should be correctly informed about the differences between energy recovery in incinerators and cement plants.

On EU level, the use of alternative fuels has significantly contributed to Unions' climate targets and reduces dependency on fossil fuels

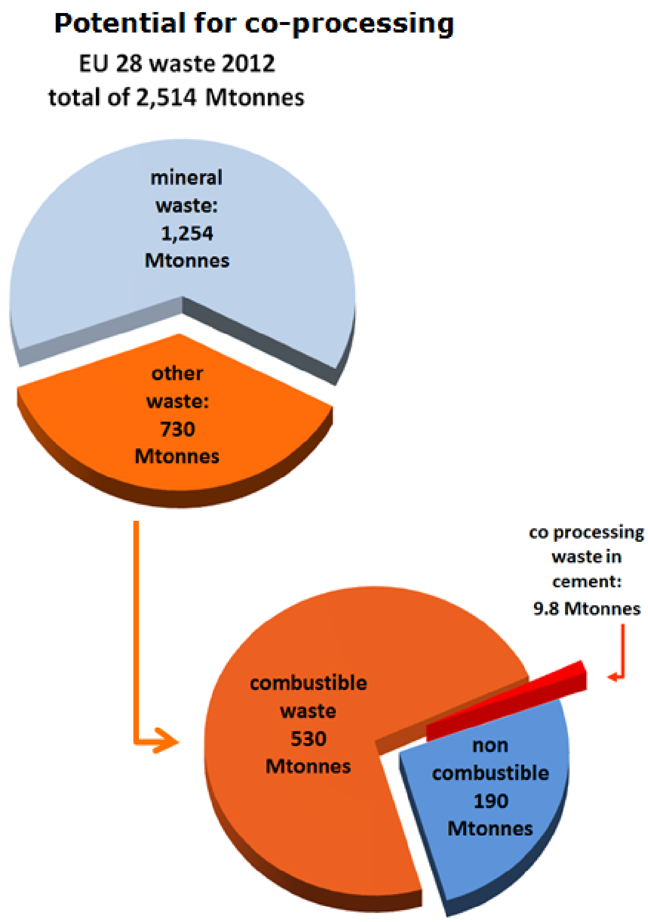
> Main fossil fuels used in the cement industry are coal and petroleum coke, with average carbon intensity 93.5 $kgCO_2/GJ$.
> CO_2 reductions can be achieved utilizing waste-derived fossil fuels or waste biomass, which is defined as being carbon neutral.
> With 2012 substitution rates at 36%, the combined use of waste biomass and waste fossil fuels helped to avoid the emission of about **16.5 Mt of CO_2, saved 177 PJ of primary energy, equaling 6.7 Mt of coal**.
> At 95% substitution rate, if similar proportion between waste biomass and waste fossil fuels is maintained, 41 Mtonnes of CO_2 could be avoided annually, alternative fuels delivering 439 PJ of energy, avoiding use of 16.7 Mtonnes of coal.
> Further reductions are arguably achieved by avoidance of landfilling (methane emissions).This waste would have been alternatively incinerated, with overall lower energy recovery when compared to clinker production.





In terms of avoided investment, to treat the current amount of co-processed waste in WtE facilities, 65 average seized WtE plants would be needed; requiring investments between 5.4 to 9.8 Billion €

> The figure to the right shows that in 2012, around 20% of waste (530 Mtonnes) in the EU was **potentially combustible**. Of this volume the cement industry co-processed 9.8 Mtonnes (1.8%).
> It is estimated, that:
  – Around 90 Mtonnes of waste are potentially 'high' in calorific value; a volume 9 times that of alternative fuel use in cement co-processing in 2012
  – The other potentially combustible waste volume of around 440 Mtonnes will need enhanced processing (sorting, drying) to be made into alternative fuel for co-processing
> Cement industry co-processing in 2012 meant:
  – providing a processing capacity **equal to 65 WtE** plants with an average capacity of 150 ktonnes/a
  – co-processing capacity represented a value of between **5.4 and 9.8 Billion EUR** in WtE plants constructed
> Achieving an EU substitution rate of 95% would mean:
  – Saving construction of an **additional 105** WtE plants
  – **Additional** avoided expenditures in new WtE plants between **8.6 to 15.6 Billion EUR**.



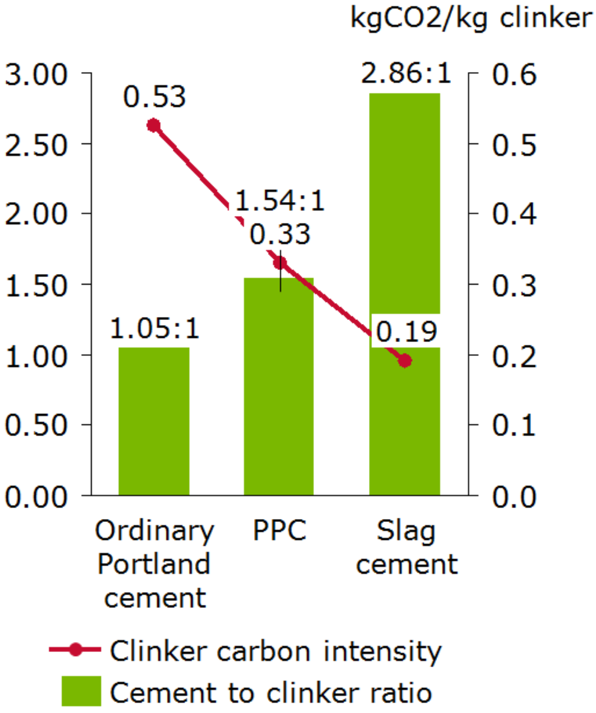
Q3 Modern cement production is aligned with circular economy principles. The sector utilizes wastes from other industries to substitute raw materials used in clinker making.

> Limestone is a principal material for clinker making. However the calcination process, necessary in cement production is very CO_2- and energy-intensive

> Simultaneous virgin material substitution and CO_2 emission reduction is possible by clinker replacements

> Wastes and by-products from other industries (e.g. blast furnace slag, fly ash) can be utilized to raise the output ratio between cement and clinker (1:1 ratio means 0 substitution)

> Ordinary Portland cement (non blended) will have about 5% gypsum composition and cement to clinker ratio 1.05:1, while Portland Pozzolana cement (PPC) (up to 30% fly ash) about 1.54:1 and slag cement constituting of up to 60% blast furnace slag has cement to clinker ratio of 2.86:1. These different types of cement cannot be utilized interchangeably however, as their use is limited by their application. (6,7)



> In many European countries however, the **increased use of lower clinker cement is limited by the availability of hydraulic and pozzolanic materials** (8)

Q3 The goal of the European cement industry is to achieve highest substitution rates possible. Individuals plants display that 60% substitution across EU should be achievable in medium-term horizon.

> In 2012, within the EU 28, the cement industry consumed 9.8 Mtonnes of alternative fuels; this equals to an average substitution rate of 36%

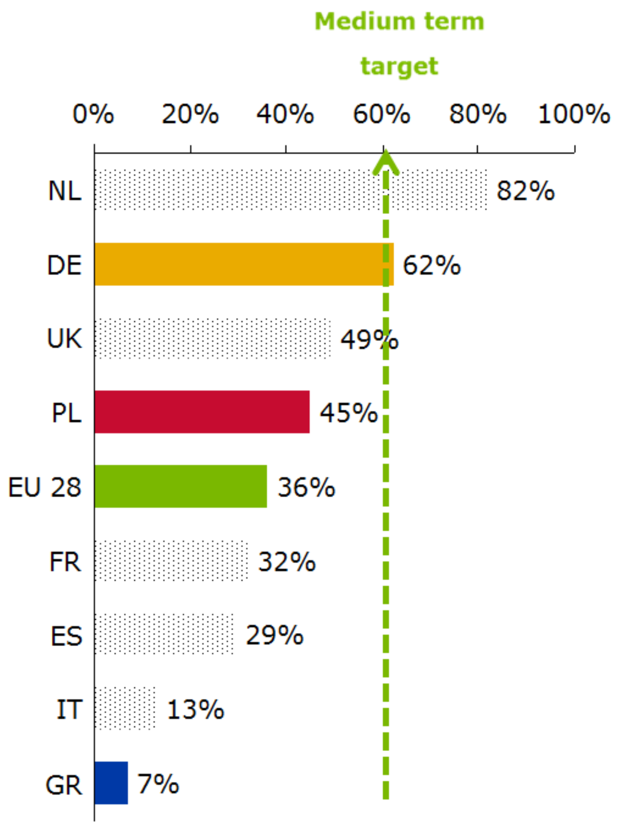
> Technically, the average cement plant in Europe could achieve 60% substitution, with some investments and adaptations

> Many individual plants already achieve substitution rates of more than 60%

> Using 2012 as a baseline, 18 Mtonnes of AF would be used by the cement industry, if 60% substitution is achieved on average

> This waste co-processing capacity amounts to an avoided investment of between 8.6 and 15.6 billion EUR, if one would use WtE plants to cover the gap between 36% and 60% substitution rate in cement production

> Using 2012 as a baseline, when achieving 60% substitution a total 10.2 Mtonnes of CO_2 could be avoided annually.



AF substitution rates in major EU countries, 2012

Summary of main findings of the study

- This study was performed for the purpose of increasing the understanding of co-processing waste in cement plants as an waste-to-energy options. *The intention was not to provide recommendations for authorities and other stakeholders.*
- The three case studies for Greece, Poland and Germany showed that **there are large differences between the Member States** regarding the status and prospects of co-processing. This leads to the conclusions that a Member State focused approach is needed to accelerate co-processing of waste. Furthermore, more case studies are required to detail the best way forward.
- This study showed that co-processing of waste in cement kilns is already being widely employed across the EU, but that **the potential for further uptake is still large.**
- There is no technical limitation at the cement plants to increase the share of alternative fuels from 36% now to 95% EU-wide. If this can be achieved it can save expenditures in additional waste to energy plants up to **15.6 billion Euro** and avoid emissions of **41 Mtonnes of CO_2 per year.**
- **There is more than enough suitable waste.** A mature waste infrastructure to collect, separate and process the waste is mandatory to increase the uptake of alternative fuels in the cement industry.
- Although appropriate EC regulations about waste management are in place, the level of compliance varies considerably between member states. **National governments play a key role** in setting the right conditions.
- Increasing the rate of alternative fuel use will require investments for the cement industry. These costs can be covered by a gate fee. However, the **willingness to pay** for advanced waste treatment varies per country, largely depending on the economic situation.
- **Market distortions** hamper the further uptake of alternative fuels in certain member states, such as inclusion/non-inclusion of carbon price for different energy recovery options and reconsideration of biomass subsidies in power generation.

Co-processing of waste can contribute to the solution of three major issues the EU is currently facing		
Climate Change 	Avoided CO_2-emissions per year EU wide	41 Mtonnes CO_2
Waste management 	Maximum amount of combustible waste that can be processed Number of incinerations plants needed to process this amount of waste	25.8 Mtonnes per year About 100
Circular economy 	Capture of mineral waste that would otherwise be landfilled Share of virgin material input for clinker production	1.4 Mtonnes Up to 5%

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References

Introduction

(1) European Commission, “Invitation to tender JRC/SVQ/2015/: Towards a better exploitation of the technical potential of Waste-to-Energy under the Energy Union,” July 2015.

(2) International Energy Agency, “Energy Technology Perspectives 2015: Mobilising Innovation to Accelerate Climate Action.” 2015, available: http://www.iea.org/etp/etp2015/.

(3) Cement Sustainability Initiative, “Getting the numbers right database,” accessed May 2015, available: http://www.wbcsdcement.org/index.php/en/key-issues/climate-protection/gnr-database.

(4) EUROSTAT database, accessed May 2015, available: http://ec.europa.eu/eurostat/data/database.

(5) Cement Sustainability Initiative, “CO2 Accounting and Reporting Standard for the Cement Industry: Cement CO_2 Protocol,” 2005, available: http://www.ghgprotocol.org/files/ghgp/tools/co2_CSI_Cement_Protocol-V2.0.pdf.

Case study Greece

(1) Hellenic Cement Industry Association, “Statistics,” accessed May 2015, available: http://www.hcia.gr/en/statistical-elements/exports/.

(2) Cement Sustainability Initiative, “Getting the numbers right database,” accessed May 2015, available: http://www.wbcsdcement.org/index.php/en/key-issues/climate-protection/gnr-database.

(3) EUROSTAT database, accessed May 2015, available: http://ec.europa.eu/eurostat/data/database.

(4) Interview with Alexandros Katsiampoulas, Titan Cement, March 2016.

(5) CEWEP, “Landfill taxes and bans,” February 2015, available: http://cewep.eu/media/cewep.eu/org/med_557/1406_2015-02-03_cewep_-_landfill_inctaxesbans.pdf.

Case study Poland

(1) SPC, production data, http://www.polskicement.pl/Wyniki-59

(2) (2) SPC, Interview with Bożena Środa, March 2016.

(3) (3) SPC, “20 lat co-processingu paliw alternatywnych w cementowniach w Polsce”, Tadeusz Radzięciak, Krakow, October 2015.

(4) (4) Switzerland Global Enterprise, “Market Report Waste Management in Poland”, http://www.s-ge.com/schweiz/export/de/blog/marktstudie-s-ge-waste-management-poland, Swiss Business Hub, APAX Consulting Group, 2013.

(5) (5) Polish Government, “Aktualizacja Krajowego planu gospodarki odpadami 2014“, https://www.mos.gov.pl/kategoria/3340_krajowy_plan_gospodarki_odpadami_2014/, 2015.

(6) (6) Clifford Chance Poland, Briefing: “Municipal waste incineration plants “, http://www.cliffordchance.com/briefings/2013/03/municipal_waste_incinerationplants.html, 2013.

(7) (7) Arcadis, The functioning of waste markets in the EU, second workshop, case 6: ”Comingled waste collection in Poland”, Mike van Acoleyen, 16 November 2015.

(8) (8) CEWEP, “Landfill taxes and bans,” February 2015, available: http://cewep.eu/media/cewep.eu/org/med_557/1406_2015-02-03_cewep_-_landfill_inctaxesbans.pdf.

Case study Germany

(1) VDZ, "Zementindustrie im Überblick, 2015", available on: https://www.vdz-online.de/publikationen/

(2) (2) Interview with Dr. Martin Oerter, VDZ, March 2016

(3) (3) VDZ, "Umweltdaten der deutschen Zementindustrie 2014", September 2015, available on: https://www.vdz-online.de/en/publications/

(4) (4) Strategie Planung Umweltrecht. S. 139-162. „Perspektiven der Verwertung von Ersatzbrennstoffen in Zementwerken, "Renato Sarc, Roland Pomberger and Karl E. Lorber, 2013.

(5) (5) Energie aus Abfall, Band 10, S. 837-852 "Ersatzbrennstoff-Kraftwerke in Deutschland und Österreich", Stephanie Thiel, 2013

Conclusions

(1) Technische Büro Hauer Umweltwirtschaft GmbH, Grundlagen zur „Phase 3 – Thermische Abfallbehandlungsanlage in Tirol", Studie im Auftrag Amt der Tiroler Landesregierung, 2010

(2) European Investment Bank, „Cardiff WtE Plant", www.eib.org/projects/pipeline/2013/20130049.htm

(3) Landesregierung Mecklenburg Vorpommern, "EBS Werk Stavenhagen" www.lung.mv-regierung.de/dateien/festkoll_plebla.pdf

(4) COWI, "New CHP Waste to Energy line in Stavanger", Norway, http://www.cowi.com/menu/service/IndustryandEnergy/Energy/thermal-power/waste-to-energy/Documents/Forus%20II%202015%20UK_maj%202015.pdf , 2015

(5) U. S. Energy Information Administration, "Updated Capital Cost Estimates for Electricity Generation Plants", November 2010

(6) Javier Merle, CEMEX and EU ETS, n.d., available: http://ccap.org/assets/Javier-Merle_CEMEX.pdf.

(7) S.P. Deolalkar, "Designing green cement plants," 1st edition, Butterworth Heinemann, 2015.

(8) CEMBUREAU, "Cements for a low-carbon Europe," 2012, available: http://www.cembureau.be/sites/default/files/documents/Cement%20for%20low-carbon%20Europe%20through%20clinker%20substitution.pdf.

List of abbreviations

AF	Alternative Fuels	GHG	Green House Gasses
BAT	Best Available Technique	MBT	Mechanical Biological Treatment
BREF	Best available technique Reference Document	MSW	Municipal Solid Waste
CAPEX	Capital Expenditures	MWe	Megawatt electric
CO_2	Carbon Dioxide	MWth	Megawatt thermal
EC	European Commission	NOx	Nitrous Oxides
ETS	Emission Trading System	PPC	Portland Pozzolana Cement
EU	European Union	RDF	Refuse-Derived Fuels
FIT	Feed in Tariff	SRF	Solid-Recovered Fuels
GDP	Gross Domestic Product	WTE	Waste-to-Energy

CO_2 emissions from clinker production and waste incineration fall under different regulations

CO_2-emissions from clinker production, including those from co-processing alternative fuels fall under the **EU ETS**. CO_2-emissions from waste incineration are excluded from EU ETS and fall under the **Effort Sharing Decision and other directives**.

Cement production

- As a major CO_2 emitter, the cement industry falls in the EU ETS, which aims to create a market for trading CO_2 emission allowances. CO_2 emissions get a price.
- There are two main sources of CO_2 in cement making – unavoidable emissions (60% of total emissions) from the chemical reactions (mainly calcination) and emission from fuel combustion (40%) (6; Conclusions).
- Currently, the sector is on the carbon leakage list receiving emissions allowances for free up to a benchmark.
- Carbon leakage is for protection of the industry against foreign competition, where carbon emissions are not internalized.

Waste incineration

- In terms of CO_2 emissions, waste incineration is not covered by the EU ETS, therefore, contrarily to the cement sector, incinerators do not have to surrender allowances for CO_2 emissions from waste

Waste to Energy costs

Recent data from various countries shows processing costs for medium sized WtE (50 to 350 ktonnes/a) in the range between 1 M EUR and 0.55 M EUR/ktonne of process capacity

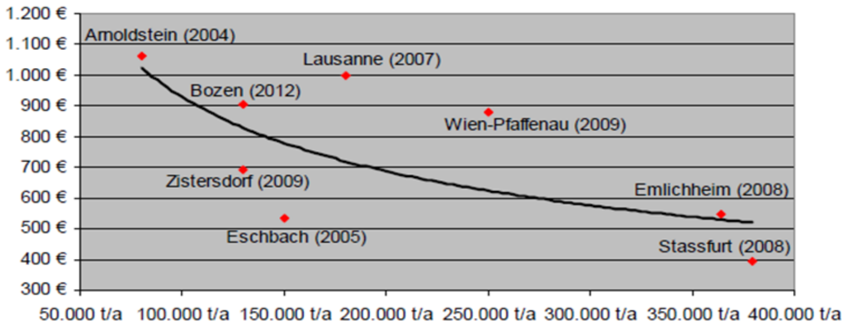
> Poland *(Source: Clifford Chance (ref. Poland (6))*
- Based on investments in 5 plants
- Between 94 ktonnes/year and 220 ktonnes/year
- Average gross cost between 354 M PLN and 797 M PLN:
  - 3.57 M PLN / ktonne of processing capacity
  - 0.85 M EUR / ktonne of processing capacity

> Germany *(Source: Landesreg. Mecklenb. Vorpom. (3))*
- EBS Werk Stavenhagen
  - 95 ktonnes/year processing capacity
  - 4,25 MWe
  - 52 M EUR invest
  - 0,55 M EUR/ktonne of processing capacity

> Norway *(Source: COWI (4))*
- Stavanger 4.3 MWe /16 MWth - WtE plant (2012)
  - 65 kt/a MSW processing capacity
  - 60 M EUR capital cost
  - 0.92 M EUR/ktonne of processing capacity

- United Kingdom *(Source: European Investment Bank (2))*
  - Cardiff WtE plant
  - 350 ktonnes/year processing capacity
  - 30 MWe production
  - Investment: 270 M EUR
    - 0.77 M EUR / ktonne of processing capacity

> Austria *(Source: Technische Büro Hauer (1))*



> USA *(Source: U.S. EIA (5))*
- Cost Estimate for a large 720 ktpa incineration plant, with 50 MW energy recovery, was $8,232/kW
- This puts US estimates within the bandwidth of costs for EU WtE plants (around 0.57 MUSD/kt)

Combustible waste streams in the EU

Analysis of combustible wastes in the EU-28 shows that 11.1% of high combustible wastes in the EU-28 were co-processed in 2012

To assess the **potential** of available volumes of Alternative Fuels from waste, statistics provided by Eurostat were used. Eurostat waste data is listed in various categories, based on 'type', 'origin' and is mass based. No data is collected with regard to the 'quality' of the waste, in terms of net content value, moisture or ash content.

For using Eurostat data in the light of the Alternative Fuel potential for the cement industry, two sets of aggregated volumes have been determined , dubbed 'High' and 'Low' combustible and based on 2012 data.

The calculated numbers are showing the **potential** in ktonnes. Most of these streams require processing and upgrading before they can be used in a kiln. The real volumes that could end up in the cement industry will thus be lower, due to losses in processing (removal of moisture, chlorine, metals, etc.).

Our assessment of the **potential is highly generalised,** *waste processing losses as well as unsuitable waste streams that also form part of the respective EWC sub numbers, are not accounted for*.

> **High Combustible (88.6 Mtonnes in 2012)**
  - Spent solvents, used oils, rubber wastes, plastic wastes, textile wastes and wood wastes.

> **Low combustible (530 Mtonnes in 2012)**
  - High Combustible + the following streams:
  - Chemical wastes, industrial effluent sludge, sludge and liquid wastes from waste treatment, health care and biological wastes, animal and mixed food waste, vegetal waste, household and similar wastes, mixed and undifferentiated materials and common sludge

Waste derived fossil and biomass fuels used in 2012			
in cement co-process	**9,800**	ktons	Relative % co process
Total waste (EU 28)	2,514,220	ktonnes	0.4%
Non mineral waste (EU	729,850	ktonnes	1.3%
High combustible	88,660	ktonnes	11.1%
Low Combustible	530,020	ktonnes	1.8%

GNR data from 2012

Eurostat data from 2012

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