Co-Processing Magazine
of Alternative Fuels & Raw Materials

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Dear Readers,

After a break of more than a year, I am pleased to announce that we can send you a new issue of our Coprocessing Magazine.

Across all media and in many conversations, I read and hear that many companies and people around the world are looking to the future with concern. Wars, unrest, but also weather disasters with droughts and floods as incipient consequences of climate change, collapsing economic data everywhere. A disenchantment with politics is spreading everywhere, which means that non-democratic parties are gaining more and more influence.

Many citizens think that they can't change anything anyway – which leads to further frustration.

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In the global cement and lime industry, too, we are seeing slumping production figures and a lot of uncertainty about the future.

Well, the saying "everyone is the architect of his own fortune" has been around in Europe since Roman times, but it still has its justification. All of us, each and every one of us, are responsible for our happiness. This not only personally, but also through his professional position.

Well, an individual cannot end wars or stop climate change, but each individual is an important building block to act as a role model through his behavior and to influence through his actions.

Each individual can contribute to the promotion of new, environmentally friendly technologies and economic practices by changing their consumer behaviour or by exerting influence. Invest in the future instead of waiting! Technologies are there – they just need to be adopted quickly. Decisions must therefore be made much faster – also in the cement and lime industry as one of the largest fossil CO_2 producers.

Some of our customers have reacted – so that we have had a lot to do again in the last year, in which we have created and are currently implementing new concepts for decarbonization in the cement and lime industry, but also for other industries, institutions and even state governments. This is a good sign, because we are directly helping to avoid enormous amounts of fossil fuel emissions and to implement an environmentally friendly and socially responsible waste management. In this issue, we have compiled some articles about the studies/concepts we have produced, and a report on technologies and processes that can help you to reduce your fossil emissions and thus look more positively into the future!

Dirk Lechtenberg
Managing Director
MVW Lechtenberg & Partner

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New Study on "Managing Refuse--derived and Solid Recovered Fuels with Best Practice Options for EU Countries" Published

On behalf of the European Investment Bank (EIB), the Duisburg-based consulting firm "MVW Lechtenberg & Partner" has prepared a study on the current use of waste-derived fuels in the European Union, which has now been published.

Refuse derived fuels (RDF) including solid recovered fuels (SRF) currently replace about 52% of the thermal energy demand of the European cement industry.

The study evaluated the current use of waste-derived fuels in industry, as well as the technical, regulatory and economic influences on their future use.

The study finds that the overall level of RDF generation in several EU Member States (MSs) is lower than the potential maximum uptake. It appears that RDF utilisation in energy intensive industrial processes could be approximately two to three times higher than is the case at present and 1.5 times higher than estimated future RDF generation.

Some other key findings are, that in some Member states, the uptake for RDF is currently significantly lower than the amount of RDF generated, leading to considerable amounts of potentially val-

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uable resources being sent to landfill and filling-up the landfills earlier than necessary.

It is possible for cement and lime producers to substitute with RDF up to 85% of their energy need currently produced from solid fossil fuels, provided that the required qualitative and quantitative specifications are met.

Many potential end-users of RDF (for example, the cement and lime industries, WtE and coal-fired power plants) are concerned about potential operational disturbances due to the frequently inconsistent quality of RDF (which can vary in terms of its calorific value and biogenic carbon, water, chlorine, and mercury content), compared to more standardised fossil fuels, coupled with uncertainty regarding the availability of feedstock. This results in potential RDF consumers continuing to use fossil fuels for operation of their main production lines, despite the higher energy costs and emissions.

To meet end-user quality requirements and ensure profitability, RDF producers must apply rigid quality control management techniques, often requiring additional investment in specialised technical equipment. New waste management plants may require relatively large investments from the outset.

For users of RDF, the shift from fossil fuels to RDF also often requires additional investments, which, however pays of in the short run.

The substitution of fossil fuels by RDF can help to reduce EU imports of primary fossil fuels, thus reducing CO_2 emissions and contributing to meeting EU landfill targets. The environmental benefit is obvious.

From a legislative point of view, the uptake of RDF by energy-intensive operators is mostly influenced by waste disposal taxes (as higher landfill and/or incineration taxes can lead to greater RDF uptake) and may also be impacted by any future revisions to the emissions trading system (ETS), such as the possible inclusion of municipal waste incineration in the ETS.

Finally, increasing EU recycling targets and implementing the waste hierarchy principle may have a negative impact on RDF quality (including its calorific value) and thus on its use in industrial kilns.

The chemical recycling of plastics in particular will have a considerable influence on the availability of substitute fuels with a high calorific value. Since the waste that has so far been thermally recycled will be separated from these waste streams in the future. Chemical recycling promises a higher value

and return the waste back to the raw material cycle, according to Dirk Lechtenberg, Managing Director of the consulting company.

Lechtenberg also sees “an incipient ‘run on biomass’, especially waste wood, which will be used in larger quantities as a substitute fuel in the future in order to reduce fossil fuel emissions in industry.

The full study can be downloaded here:
Managing refuse-derived and solid recovered fuels (eib.org)

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Figure 1: *RDF for lime kilns.*

Decarbonizing Lime Kilns with Alternative Fuels

This article has been published by our company in the recent issue of Cement Lime Gypsum ZKG magazine in June, 2023.

When burning lime, approx. 30% of the CO_2 emissions are fuel related emissions. While the use of alternative fuels, such as refuse derived fuels is common practice in the cement industry, the use of alternative fuels in the lime industry is still in its early stages. In the following, the opportunities for the use of various types of alternative fuels such as refuse derived fuels in modern lime kilns are summarized.

Lime is a mineral product derived from limestone by an industrial process. Naturally occurring limestone is composed almost exclusively of calcium carbonate. The lime production process is based on a chemical reaction induced by heating calcium carbonate ($CaCO_3$) to produce quicklime (CaO). Inevitably, this reaction also produces CO_2. These emissions of CO_2, which are inherent to the lime production process, are called process emissions. These process emissions alone constitute 70% of the total CO_2 emissions from the lime production process, and they cannot be avoided.

The annual production capacity for lime has increased significantly over the years. In 2013, the worldwide lime production was 350 million t, and it has increased to 430 million t in 2022 [6, 7].

High quality requirements

The lime industry is a highly energy intensive industry with energy accounting for 30-60% of total production costs. Kilns are fired with fossil fuels, such as solid, liquid or gaseous fuels as well as – in a very low level – with refuse derived fuels

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or biomass. The use of refuse derived fuels (RDF) depends on the expected lime quality, as RDF can have an effect on lime quality. In order to understand the high quality demands placed on the fuels for lime production, it is useful to look at the main applications of the lime produced. Lime is a pure chemical product with >98% active CaO that is used in a wide range of applications, including in the food and pharmaceutical industries. In the following we refer exclusively to quicklime, or so-called 'burned lime'. Quicklime is calcium oxide (CaO) produced by the decarbonisation of limestone ($CaCO_3$) and represents approx. 90% of the produced lime.

To understand the limiting factors for the use of alternative fuels in lime production, it is useful to compare the typical composition of limestone with representative analyses of alternative fuels, such as those used in the German lime industry, and ashes from such alternative fuels.

Due to the areas of application of the various lime products, the use of alternative fuels in lime production is often prohibited, since undesirable impurities, trace elements, etc. are also added to the pure lime product in the form of ash via the fuel. In general, therefore, when using alternative fuels for the lime industry, the ash content should be limited to less than 6–10%, depending on the lime product. For certain applications, e.g. in the food or pharmaceutical industry, the use of waste-derived alternative fuels should therefore be excluded. Further restrictions are to be examined on a case-by-case basis.

Other alternative fuels can have a positive influence on the lime grades produced. For example, the use of meat-and-bone meal as an alternative fuel for lime products was shown to be positive for the fertilizer sector, due to the P_2O_5 content in meat-and-bone meal.

High demands are also placed on the nitrogen content of alternative fuels. Tests have shown that finely ground woody biomasses contain a nitrogen content of up to 1%. Major constituents in wood are carbon (from 45 to 50% of the mass), followed by oxygen (about 40-50%), hydrogen (about 6%), and nitrogen (up to 1%) [8].

The flue gas temperature at parallel flow regenerative kilns (PFRK) is just above 100°C, with a Lambda of slightly above 1. In order to reduce the NOx emissions by an SCR System, the flue gases need to be reheated in order to comply with the NOx limit of 350 mg.

Technical requirements for the use of solid alternative fuels in lime kilns

Lime is produced in various kiln types. The heat consumption varies on these different kiln types, so that many lime companies have invested in parallel flow regenerative kilns (PFRK). The use of solid alternative fuels in rotary kilns is well known from the cement industry. Standard refuse derived fuels or solid recovered fuels in a grain size of up to 30 mm without three dimensional parts is fed pneumatically through a dedicated feeding line through the main burner. This is common practice in the lime industry, and most of the more energy intensive rotary lime kilns in Europe are using such alternative fuels. Liquid waste fuels can be used in rotary kilns (LRK, PRK), annular shaft kilns (ASK), parallel flow regenerative kilns (PFRK) and special types of other kilns (OK), e.g. regular shaft kilns with side burner and double-incline kilns.

When solid fuels are pulverised, they can be used in all the above-mentioned types of kilns. Bigger grain sized refuse derived fuels of up to 30 mm can only be used in rotary kilns (LRK, PRK).

Technical requirements in ASK and PFRK kilns

Annular shaft kilns (ASK) and parallel flow regenerative kilns (PFRK) have a different feeding and dosing system for fuels. In such kilns, the fuel is provided to a number of lances in the combustion zones. The lances, typically with a diameter of only 18-30 mm providing the fuel in small quantities of between 30-150 kg per lance/per hour.

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A PFRK can have up to 36 lances, arranged as ring line around the kiln. the fuels are provided through a dedicated pneumatic feeding and weighing systems which are pressure surge resistant and able to provide constant and homogenous feeding of pulverized alternative fuels up to 3-5 mm. In ASK, even small alternative fuel pellets of up to 8 mm length and 6 mm diameter can be fed into the upper burners. Such dedicated dosing and feeding systems are provided by a number of companies, such as Carbotech (Germany), Esch (Germany), Maerz (Switzerland) and Schenck Process (Germany).

Fuel physical quality requirements

When using solid alternative fuels in lime plants, specific requirements on the physical parameters are given. Kilns can be either equipped with feeding systems for pellets in a size of max. 8 mm length or milled fuels in a grain size of <5 mm. MVW Lechtenberg's daughter company "Blue River Recycling" produces in its processing facility in the port of Papenburg, Germany dedicated pellets for the lime industry as well as pulverised fuels. With a capacity of more than 100.000 t/a, mixed waste is sorted, dried and processed into pellets.

The pellets consist either purely of mixed plastic waste, or mixtures of e.g., up to 75% wood and 25% plastics in order to achieve a minimum calorific value of 21.5 MJ/kg, which is equal to the calorific value of ground lignite, which is currently widely used in the German lime industry.

RED III – CO_2 emission reduction while using alternative fuels

Lime production releases CO_2 emissions through the calcination of limestone and the use of fossil fuels. The emission factors are shown in the below table. For the process related emissions, the lime industry is currently developing several projects for carbon capture in order to minimize the environmental impact.

Since the introduction of the Renewable Energy Directive (2009/28/EC) in 2009, the deployment of renewables has kept growing yearly, reaching 21.8% in 2021. In July 2021, the Commission proposed another revision to accelerate the take-up of

Figure 2: *Milled refuse derived fuel for lime kilns.*

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Figure 3: *Pellets – 6mm RDF/wood mixture (top), 16mm RDF (middle), 6mm wood (bottom).*

renewables in the EU and to help reaching the 2030 energy and climate objectives [1].

The ambition and measures in the directive have been reviewed several times in order to deliver the urgent emission cuts (at least 55% by 2030) that are required to achieve the EU's increased climate ambitions. In July 2021, the Commission proposed a revision of the directive (COM/2021/557 final) with an increased 40% target as part of the package to deliver on the European Green Deal. In May 2022, the Commission proposed in its Communication on the REPowerEU plan (COM/2022/230 final) to further increase this target to 45% by 2030. The Council and the Parliament negotiators reached a provisional political agreement on the 30th of March 2023 to raise the share of renewable energy in the EU's overall energy consumption to 42.5% by 2030 with an additional 2.5% indicative top up that would allow reaching 45% [2].

On April 18th, the European commission agreed on new emission reduction goals within the "Fit for 55" package. The "Fit for 55" package is a set of proposals to revise and update EU legislation and to put in place new initiatives with the aim of ensuring that EU policies are in line with the climate goals agreed by the Council and the European Parliament [3]. The EU agreed to cut overall CO_2 emissions by 2030 at least by 55% compared to 1990. It was further agreed to reduce the free CO_2 allocations for the industry step by step and stop free allocations by 2034. This will boost the need for more alternative fuels such as refuse derived fuels or solid recovered fuels with a high biogenic content to enable the lime industry to reduce the fossil CO_2 emissions.

By using alternative fuels in the lime industry, the biogenic content (means locally available wood, tree trimmings, but also biogenic parts such as non-recyclable paper and cardboard, textiles etc.) will have a significant influence on fossil CO_2 savings.

In the following, a cost comparison of fossil fuels and RDF pellets as well as wood pellets is shown. The RDF pellets mainly consist of non-recyclable plastics as well as wood. The CO_2 price was given with 90 €/t (EU/ETS).

Summary

Lime production is an energy intensive process. The European Lime Association (EuLA) states that the lime industry decarbonisation measures are mainly 'end-of-pipe' solutions, such as carbon capture and storage or usage and carbonation, as 68% of the industry's CO_2 emissions are derived from the processing of raw materials. It is estimated that

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Description	Lignite dust	Coal dust	RDF pellets	Wood pellets
Net calorific value (MJ/kg)	22.1	28.1	21.5	17.3
Moisture (%)	9	1.7	7	9
C total (%)	59,5	80	53	46
C biogenic (%)	0	0	20,75	46
CO_2 total (t CO_2/t fuel)	2.18	2.93	1.94	1.69
CO_2 biogenic (t CO_2/t fuel)	0	0	0.76	1.69
CO_2 fossil (t CO_2/t fuel)	2.18	2.93	1.18	0
CO_2 fossil (t CO_2/TJ)	99	104	55	0
CO_2 price (Europe)	90 €/t			
CO_2 costs (€/t fuel)	196	264	106	0

Table № 1: *Comparison of costs savings while using RDF pellets.*

approximately 400 Mt/a of CO_2 are released into the atmosphere by the lime industry.

App. 30% of the fossil CO_2 emissions are fuel related. By using pelletized or pulverised alternative fuels with a high biogenic content, this could be a "low hanging fruit" to significantly reduce fossil CO_2 emissions by using existing and economic technologies.

Other alternative fuels, such as syngas (produced from processed alternative fuels), hydrogen (from renewable energy sources and biogas (from anaerobic digestion plants) can complement a 100% fossil free fuel supply to the lime industry.

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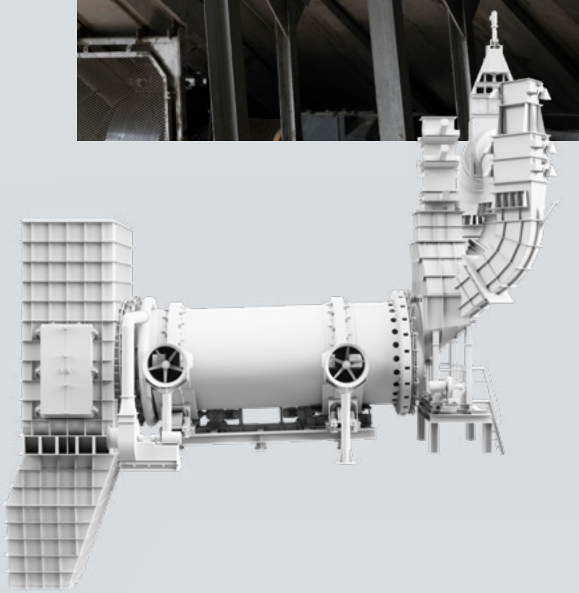

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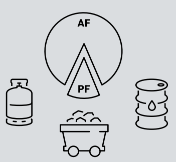

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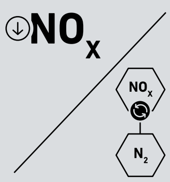

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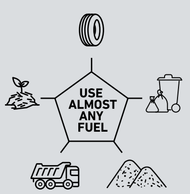

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Possible Effects of Bio-farming, Combined with CO_2 Absorption

By Vladimir Dimitrov, MVW Lechtenberg & Partner

Due to the EU Green Deal the "Carbon Footprint" became an important topic for many industrial sectors. In particular the heavy industry (cement, steel, power plants, etc.) which is involved in the carbon trading system since January 2005, is heavily affected. But also, other subsectors, with companies having more than 500 employees in 2022, are obliged to estimate and report their carbon footprint (in accordance with the criteria for the EC taxonomy), and find solutions how to offset emissions and become environmentally neutral.

For example, the cement industry currently emits around 8% from the global CO_2 emissions [1]. In comparison, the agricultural sector is contributing with around 20% (2017) [2]. In this connection, the basic points in the plan of the European Commission regarding the ecosystems and biodiversity addressing measures to deal with soil and water pollution, as well as a new forestry strategy, both in cities and in the provinces and involve the following goals by 2030:

- High-diversity landscape features – 10% of the UAA [3]
- 50% less nutrient losses and 50% less antimicrobials
- 20% less fertilizers and 25% of the UAA [3] to be land under organic farming

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The agriculture and CO_2 contribution today

Agriculture is currently one of the most significant contributors to the GHG emissions globally. The five main processes involved in crop production are shown in the next table.

Nitrous oxide warms the planet 300 times as much as carbon dioxide [7].

Regarding the pesticides – the agricultural sector has recently advocated switching chemical sources with organic active elements to biological or biodynamic growing methods. The farmers have adopted

***Table № 1:** CO_2 contribution per activity per crop specie in percentages [4].*

Carbon contribution per product / crop	Rice	Cotton	Maize	Soybeans	Wheat	Average
Crop protection products	1%	4%	1%	2%	1%	2%
Fertilizer products	29%	34%	61%	28%	46%	40%
Fertilizer application	65%	18%	31%	15%	26%	31%
Energy & Fuels	2%	43%	6%	19%	21%	18%
Other input	3%	3%	1%	36%	6%	9%
Total	100%	100%	100%	100%	100%	

Around 70% to 90% of the environmental impacts of agricultural production emerge from the primary production process [5]. It is obvious that the major CO_2 contributor in the agriculture are the fertilizers (production and application). **But this uptick in fertilizer use has come at a cost, to wit planet-warming greenhouse gas emissions.** Globally, agriculture is the second-largest source of climate change pollution and both the manufacturing and application of fertilizer has a heavy emissions toll [6].

Ammonia itself is the second-most commonly produced chemical in the world, used in huge quantities as a very effective fertilizer. However ammonia production needs a lot of energy, which emit CO_2 that contributes between 1 and 2% of worldwide CO_2 emissions [6].

The crops only take up about 50% on average of the nitrogen from the fertilizers. Much of the applied fertilizer runs off into waterways, or gets broken down by microbes in the soil, releasing the potent greenhouse gas nitrous oxide into the atmosphere.

the use of seeds coated with toxic pesticides such as neonicotinoids to manage with the insects. The use of neonicotinoids, which kill insects by blocking nerve impulses, have caused a 40% decline of insects, including pollinators [8]. Pesticides over time accumulate in the human body and can lead to a variety of illnesses.

An analysis shows that pesticide manufacture, distribution, and application jointly account for annual emissions of 19.9 million metric tonnes carbon equivalent that are equal to the yearly output of 18.4 coal-fired power plants [9].

The soil properties such as soil temperature, soil moisture, water-filled pore space (WFPS), and soil micro-ecology can also influence the carbon footprint. The temperature was documented as a major driver of CO_2 fluxes and microbial activity. If other conditions remain similar, increases in soil temperature result in higher emissions. Higher soil respiration rates are positively associated with microbial activities but negatively associated with soil O_2 content.

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Changes in land use might have a significant impact on soil parameters and this can alter the source-sink balance of atmospheric GHG emissions. **Some soil organic matter may also be oxidized to carbon dioxide emission via tillage.** The SOC (Soil Organic Carbon) might be stabilized by three mechanisms in soil – physical protection, chemical composition and biological stabilization.

It is estimated that the global soil carbon pool to one-meter depth is around 2,500 Pg (petagram) of carbon. This is about 3.2 times the size of the atmospheric pool and 4 times that of the biotic pool. The carbon loss and soil carbon sequestration are two components of building this carbon in soils depending on management practices such as reduced tillage, good quality of pasture, green manures, manures, composts, and other sources of organic matter. The quality and quantity of soil organic matter, therefore, have a critical role in carbon balance worldwide [10].

At the current rates of soil destruction (i.e., erosion, desertification, chemical pollution), eventually, we will not have enough fertile topsoil to feed ourselves. Human health is at risk the longer that pesticide use and climate change interact.

__Table № 2:__ Energy use in farm operations, and its conversion into carbon equivalent (CE) [11].

Tillage operations	Range [per 1,000 m²]
Spraying chemicals	0.1 kg CE
Drilling or seeding	0.2 – 0.4 kg CE
Combine harvesting	0.6 – 1.2 kg CE
Conventional & Chisel/Minimum till	0.8 – 3.5 kg CE
Fertilizer nutrients	
N, $P_2 0_5$, $K_2 0$, lime	0.03 – 1.8 kg CE/kg
Different pesticides	
Herbicides, insecticides, fungicides	3.9 – 6.3 kg CE/kg
Irrigation, lifting water, sprinkling systems	
Apply of 25 and 50 cm of water	129 / 258 kg CE

Carbon sequestration by plants

Carbon is the basic element in all living organisms and is the vital building block for life. Organic carbon is present in various forms, mostly occur as plant biomass and organic matter in soil. Trees capture CO_2 by fixing carbon during the photosynthesis process and accumulating extra carbon as biomass. Plants grow through the natural process of photosynthesis, in which CO_2 is captured and stored in cells of the plants.

The figure 1 shows the estimated average amount of carbon stored by different forest components, in terms of tonnes of carbon stored per hectare including [12] Trees (Tree_AGC), Shrubs (Herb_AGC), Deadwood (DW_C), Leaf litter (Litterfall_C), Roots (Root_C), Soil carbon (SOC).

The presence of a red arrow indicates that tree diversity has had a positive impact on that particular carbon stock, while a blue arrow indicates that the age of the forest has had a positive impact. On the diagram, the grey boxes show the results for temporary exchanges of carbon – known as "carbon fluxes". The white boxes show the results for long-term carbon stocks. To the right, the total forest carbon stock (Total_C), above-ground carbon (AGC_total), ground carbon (GC_total) and below-ground carbon (BGC_total) is indicated [12].

The result recalculated in Table № 3 for 1,000 m² shows that the average amount of carbon stored from all species across the plots is around 37 tonnes, from which 39% above ground and 54% below ground. Per unit the trees carbon storage contribution is 47% (trees, roots and leaf litter), the soil with 43.5% and the rest (shrubs, deadwood) with 9.5%.

The results in Table № 4 are calculated based on CO_2 sequestrated by area, divided by the number of 20 years old trees in that

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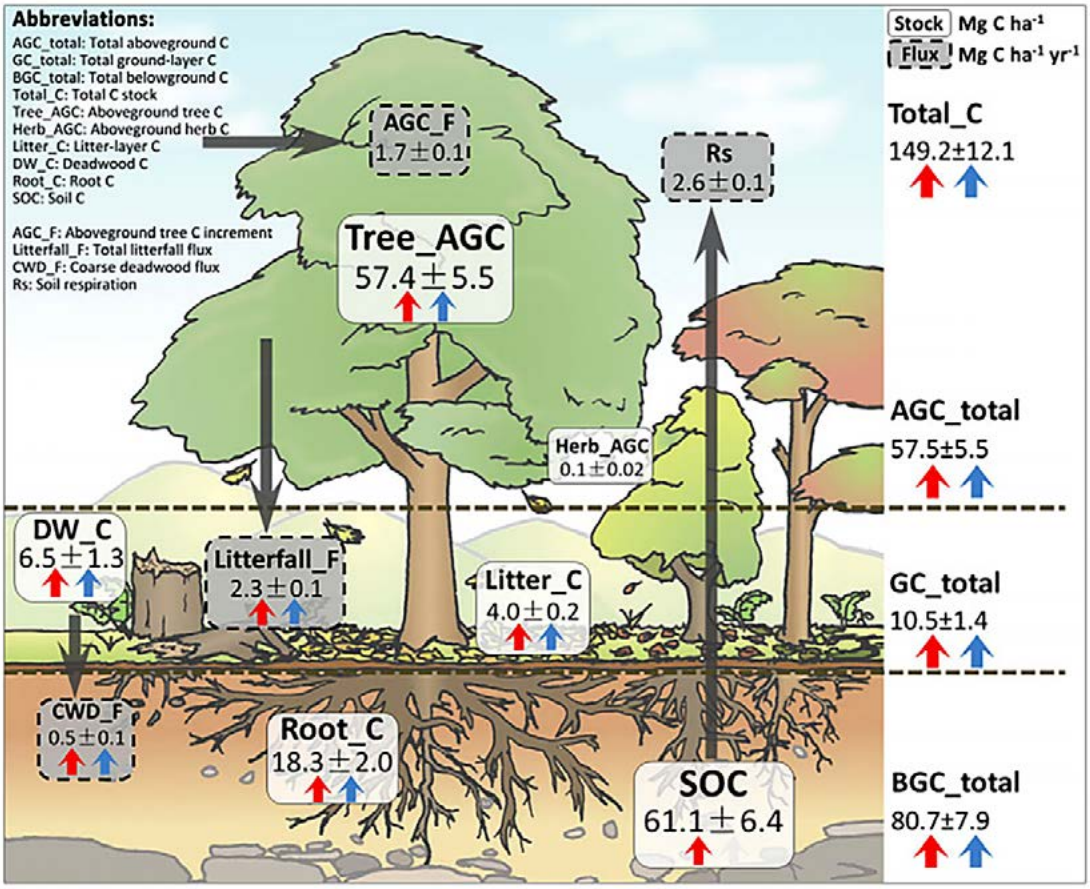

***Figure 1:** Estimated average amount of carbon stored by different forest components, in terms of tonnes of carbon stored per hectare (10,000 m²) [12].*

area, which gives very general impression, but not very accurate.

How much carbon dioxide does a single mature tree absorb?

Typical way of estimation of CO_2 sequestration is physically measuring each tree, based on its height, stem width, wood density of the tree species and age. Ultimately, the growth of each tree is non-linear, and the greatest sequestration stage is in the younger stages of tree growth, depending on rates and peaks of individual species, with the sequestration of CO_2 per year dropping thereafter.

The main tree growth factors are the type of tree species, local climate, growth conditions, water availability, sunlight, soil nutrients, site specific factors. The types of tree lands/forests are differentiated and shown in the next table.

Table № 5 shows that between 4.5 and 40.7 tonnes of CO_2 are removed per year per hectare during the first 20 years of tree growth **(0.45 – 4.07 tCO_2 per year per 1,000 m²)** [13].

What is the number of trees in 1,000 m² forest?

Generally, the number of trees planted per hectare (10,000 m²) will vary from 1,000 to 2,500 trees (100 to 250 trees per 1,000 m²), but the number will vary significantly, depending on the species and the type of planting. A native, mixed woodland could contain around 1,600 trees per hectare (160 trees per 1,000 m²), while a 'tiny forest' will be planted much more densely (1,200 trees per 1,000 m²). Fruit trees are typically smaller, and you can opt for dwarf varieties if space is particularly tight, but you'll need to leave broad avenues between them to allow for fruit gathering [14].

Besides CO_2 the trees also remove other gaseous pollutants such as sulfur dioxide (SO_2), ozone (O_3), nitrogen oxides (NOx), particulates.

Some of the tree's species with high CO_2 absorption potential are:

- **Broad-leaved tree species** – Virginia live oak, black walnut, American sweetgum, London plane, red oak, common horse-chestnut, scarlet oak.

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Forest segments	Average carbon storage per year			
	per 1.000 m²			per unit
Trees (Tree_AGC)	Above-ground carbon	39%	14.3 tonnes	11.9 kg/tree
Shrubs (Herb_AGC)			0.0 tonnes	0.1 kg/m²
Deadwood (DW_C)	Ground carbon	7 %	1.6 tonnes	3.3 kg/m²
Leaf litter (Litterfall_C)			1.0 tonnes	0.8 kg/tree
Roots (Root_C)		54 %	4.6 tonnes	3.8 kg/tree
Soil carbon (SOC)	Below-ground carbon		15.3 tonnes	15.3 kg/m²
Total		100 %	36.8 tonnes	

***Table № 3:** Estimated average amount of carbon storage by different forest components, in terms of tonnes of carbon storage per 1,000 m².*

Per tree / year	Absorption part
4.7 kg CO_2	In the leaves & branches
0.9 kg CO_2	In the stem
6.7 kg CO_2	**In the roots**
12.4 kg CO_2	**Total per tree**

***Table № 4:** Distribution of CO_2 in kg per year in the different tree parts for a single tree.*

FLR activity	CO_2 removal rate over 20 years
Planted forests and woodlots	4.5-40.7 t CO_2/ha/year
Mangrove restoration	23.1 t CO_2/ha/year
Natural regeneration	9.1-18.8 t CO_2/ha/year
Agroforestry	0.8-15.6 t CO_2/ha/year

***Table № 5:** Range of CO_2 removal rate over period of 20 year per type of planted area.*

- **Coniferous tree species** – baldcypress, red pine, eastern white pine, douglasfir, ponderosa pine

In order to obtain accurate and realistic assessment of the sequestrated CO_2 from a plot of land, measuring of each plant (tree, bush, grass, etc.) and the soil, has to be carried out annually.

The CO_2 impact of agroforestry farms

Agroforestry Farming Systems mean planting crops between rows of trees to provide income while the trees mature. The system can be designed to produce fruits, nuts, vegetables, grains, flowers, herbs, bioenergy feedstocks, and more.

What if an agroforestry farm planted with various plants according to the EU Green Deal targets and the CO_2 sequestrated from the farm is used for credits to offset a company activity? Let's assume that we have a plot of land of 1,000 m² and we want to make an agroforestry farm, with a combination of trees (fruit, nuts, others), grass and vegetables. Furthermore, we want to determine what environmental and economic effects will be obtained in terms of:

- Net CO_2 balance
- Food production
- Other benefits

The land plot of 1,000 m² has the following dimensions: 25x40 meters. The following species distribution (Figure 2) is grown and observed for period of the first 5 years:

- Fence from elephant grass (Miscanthus Giganteas) – 65x2 meters or 130 m². We assume that it grows from single rhizome in the first year, reaching full growth of 130 m² in the 5th year.
- Fruit trees – planting density of 3x3 meters or 103 trees with total area of 620 m². We assume that the tree's growing rate is 2.5 cm per year in diameter and 0.5 meters in height. So, with starting trees size of 2.5 cm in diameter and 1.5 meters height in the first year, at the fifth year we have 12.5 cm diameter and 3.5 meters height.

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Possible Effects of Bio-farming, Combined with CO_2 Absorption

- Vegetable garden – planting density of 1x1 meters or 313 plants with total area of 250 m². It can be yearling or perennial specie. However, in this case we consider to plant zucchini, which are yearling and have to be planted every year.
- Additionally, we assume that from the available underground area 74% is soil, and the rest 26% is occupied by the roots of all plants – trees, vegetables, grass. We assume that in the worst case, the CO_2 sequestrated in the soil will remain the same, and slightly increase if minimum or no tillage is done.

In order to determine the CO_2 absorption of each type of area – grass fence, tree plots, garden area and soil, we use the following measuring methodology:

- Non-destructive method for the trees – including the measurement of height and diameter of the tree. The height of the tree is calculated using a total station instrument. The diameter is determined by using a measuring tape. The procedure is performed once per year for all the trees.
- Destructive method for the garden species (zucchini and miscanthus) – by taking one of the plants (above and underground part, including the fruits) as a sample for laboratory analysis and determination of the CO_2 absorption. The procedure is carried out once per year for one plant and then estimated for all others.
- To calculate the belowground biomass and CO_2 absorption, respectively, soil samples are taken and analyzed. The procedure is done once per year for one cumulative sample.

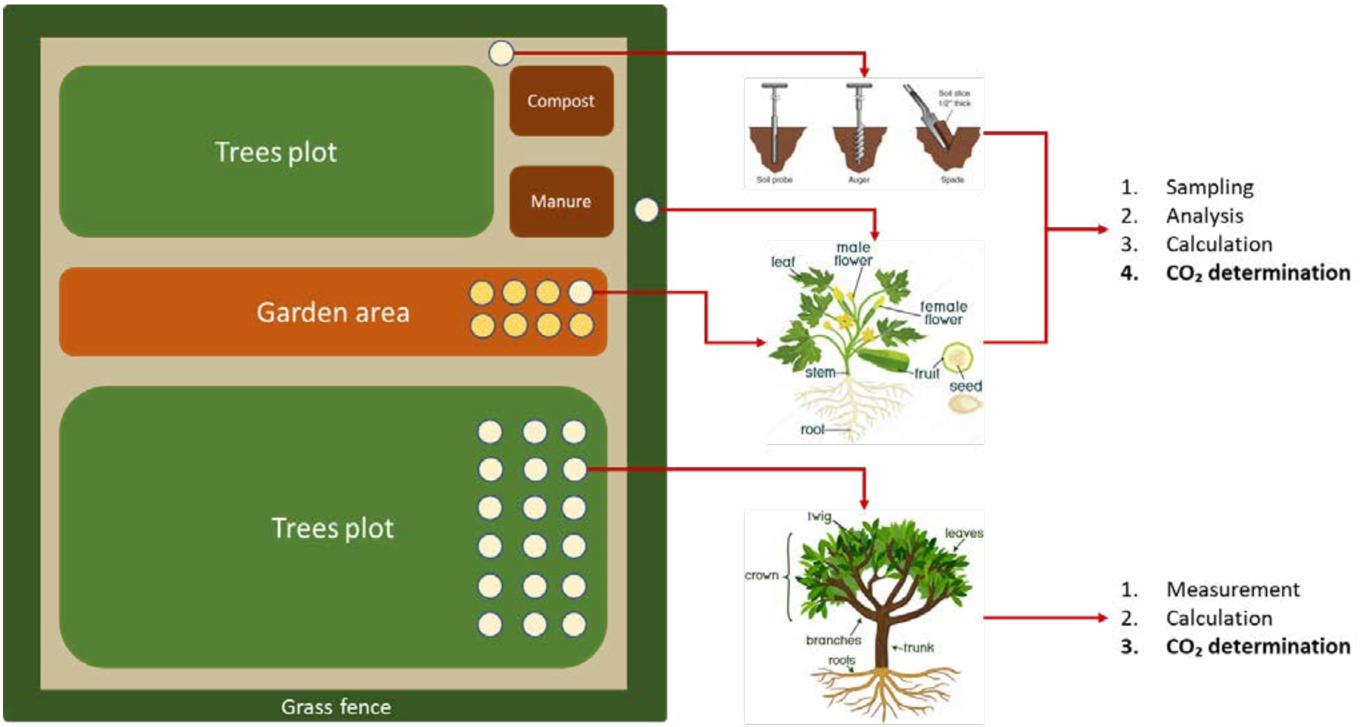

Figure 2: *Diagram of the species distribution in land plot of 1,000 m² with dimensions of 25x40 meters, and measures to be taken.*

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Table № 6 shows the estimated results, based on the growing rate parameters according the above-described methodology for a period of 5 years.

The total CO_2 absorbed by the 1,000 m² plot of land at the end of the 5th year amounts to 12.2 tonnes. The annual CO_2 contribution of the plot is shown in blue, taking into consideration the first year as baseline. According to the estimations from the above-described methodology:

- The trees will absorb on average **19%** more CO_2 each year, due to the growing rate above and below the ground.
- The grass will absorb on average **16%** more CO_2 each year, due to the growing rate in height above the ground and widespread of the rhizomes.
- The zucchini and soil will absorb on average **5%** more CO_2 each year, due to the biomass (leaves, roots, fruits, etc.) accumulated (or left) in the ground after each season.

As we can see, around 90% of the absorbed CO_2 is concentrated in the trees and the soil, and 46% (5,580 kg) from the trees and 45% (5,501 kg) from the soil, respectively.

The estimation of the CO_2 footprint for cultivation of the 1,000 m² plot of land takes into consideration the following parameters:

- Till of seedbed preparation – **0.6 kg CE** (Table № 2)
- The drilling of seeds is done manually
- Harvesting of fruits and vegetables is done manually
- Compost and manure applications
- No use of chemicals and pesticides
- Irrigation – **64.5 kg CE** (Table № 2) for lifting of the water.
- Logistics in 3 scenarios:
  - ✓ Scenario 1 – **315 kg CE** (1,051 g CO_2/km [15]) for transportation by ICE (internal combustion engine) truck with distribution of the production (vegetables, fruits and biomass) in radius of 50 km around the land plot, based on 3 hauls per 1,000 m².
  - ✓ Scenario 2 – **132 kg CE** (441 g CO_2/km based on country energy mix) for transportation by EV (electrical vehicle) truck with distribution of the production (vegetables, fruits and biomass) in radius of 50 km around the land plot, based on 3 hauls per 1,000 m².
  - ✓ Scenario 3 – **0 kg CE** (based on 100% renewable energy) for transportation by EV truck with distribution of the production (vegetables, fruits and biomass) in radius of 50 km around the land plot, based on 3 hauls per 1,000 m².

The estimation of the Company's footprint takes into consideration the following parameters [16]:

- Location – Bulgaria
- Small company with 6 employees

	Amount		Year 1	Year 2	Year 3	Year 4	Year 5	CO_2 absorbed	
Total area	100%	1.000 m²	CO_2	CO_2	CO_2	CO_2	CO_2	total	avg. increase
Trees	26%	103 pieces	103 kg	413 kg	930 kg	1,550 kg	2,583 kg	5,580 kg	19% per year
Grass		130 m²	75 kg	94 kg	126 kg	189 kg	377 kg	861 kg	16% per year
Zucchini		313 pieces	219 kg	230 kg	241 kg	253 kg	266 kg	266 kg	5% per year
Soil	74%	741 m²	4,526 kg	4,752 kg	4,990 kg	5,239 kg	5,501 kg	5,501 kg	
CO_2 absorbed			4.9 tCO_2	5.5 tCO_2	6.3 tCO_2	7.2 tCO_2	8.7 tCO_2	12.2 tCO_2	
CO_2 contribution			0.0 tCO_2	0.6 tCO_2	0.8 tCO_2	0.9 tCO_2	1.5 tCO_2		

Table № 6: *Results for CO_2 rate absorption per specie for 5 years' period.*

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- Workplace – 200 m² in an office building
- Office energy consumption – 200 kWh per month
- Country energy mix – 20% renewable energy, 40% nuclear, 40% fossil fuels (coal)
- Employees' mobility – 5 company cars (hybrid vehicles)
- Total kilometers – 120,000 km per year (5 cars by 20,000 km per year)
- Fuel consumption – 5 liters gasoline per 100 km
- Flights – 5 short range round-trip flights per year (< 3,000 km or < 6 hours one way)
- Separate garbage system

Two scenarios for the estimations have been contemplated, with main difference in the energy mix:

Company's footprint scenario №1 shows 39 tonnes of CO_2 emitted annually. However, we can exclude the "Food" factor, due to the fact that this is concerning each employee individually and not the Company. In this sense, we assume the Company's CO_2 footprint for offsetting is 27 tonnes annually.

- Country energy mix – **as defined above**

Company footprint scenario №2 shows 22 tonnes CO_2 emitted annually. Excluding the "Food" factor, we assume the Company's CO_2 footprint for offsetting is about 11 tonnes annually. The difference from scenario 1 is based on:

- Country energy mix – **100% renewable energy**
- Employees mobility – 5 company cars **(EV vehicles)**

Table № 8 shows what would be the CO_2 offset development of the Company for a period of 5 years, by using a plot of land of 1,000 m², with 0.4 t CO_2/year cultivation footprint (logistics based on Scenario №1) and 0.2 t CO_2/year cultivation footprint (logistics based on Scenario №2).

The last column shows that in order to offset 100% of the CO_2 emissions and that the Company becomes carbon neutral by the 5th year, around 8,200 m² of agroforestry farm is required.

The estimation of the economic results from 1.000 m² land plot

The incomes are based on:

- Due to no use of fertilizer and pesticides, we assume 50% lower yield for plums and zucchini.
- Gradual, 5 years yield increase is taken into consideration.
- Typical average market prices.

The next table shows the potential annual income for each type of product – fruits, vegetables, biomass and CO_2 credits.

The expenses are based on:

- Typical cultivation cost in Bulgaria of 1.1 euro per m² including cultivation, irrigation, harvesting and logistics. The annual expense is 1,100 € for 1,000 m².

Based on the balance (Table № 10) we can see that even with pessimistic yield, there is a positive

39 tCO_2/year	100%	Total		22 tCO_2/year	100%	Total
4.7 tCO_2/year	12%	Energy		3.3 tCO_2/year	15%	Energy
17.6 tCO_2/year	45%	Mobility		3.1 tCO_2/year	14%	Mobility
4.3 tCO_2/year	11%	Flights		4.2 tCO_2/year	19%	Flights
12.5 tCO_2/year	32%	Food		11.4 tCO_2/year	52%	Food
27 tCO_2/year	**68%**	**to Offset**		**11 tCO_2/year**	**48%**	**to Offset**

Table № 7: *CO_2 footprint of the Company for scenario №1 (left table) and scenario №2 (right table).*

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	Annual contribution					Company				Land required	
	CO_2 absorbed	CO_2 emitted		CO_2 Net		Footprint		Offset		100% offset	
		Scen. 1	Scen. 2	Scen. 1	Scen. 2	Scen. 1	Scen. 2	Scen. 1	Scen. 2	Scen. 1	Scen. 2
Year 1	0.0 tCO_2	0.4 tCO_2	0.2 tCO_2	-0.4 tCO_2	-0.2 tCO_2	27 tCO_2	11 tCO_2	0.00%	0.00%		
Year 2	0.6 tCO_2	0.4 tCO_2	0.2 tCO_2	0.2 tCO_2	0.4 tCO_2	27 tCO_2	11 tCO_2	0.70%	3.50%	142,806 m²	28,641 m²
Year 3	0.8 tCO_2	0.4 tCO_2	0.2 tCO_2	0.4 tCO_2	0.6 tCO_2	27 tCO_2	11 tCO_2	1.60%	5.70%	63,627 m²	17,606 m²
Year 4	0.9 tCO_2	0.4 tCO_2	0.2 tCO_2	0.6 tCO_2	0.7 tCO_2	27 tCO_2	11 tCO_2	2.10%	7.10%	47,021 m²	14,136 m²
Year 5	1.5 tCO_2	0.4 tCO_2	0.2 tCO_2	1.1 tCO_2	1.3 tCO_2	27 tCO_2	11 tCO_2	4.20%	12.30%	**23,762 m²**	**8,129 m²**

Table № 8: *5 years development of Company CO_2 offset by land plot of 1,000 m², according to Scenario №1 and Scenario №2.*

	Plum trees			Zucchini garden		CO_2 absorbed			Miscanthus		Total
	Yield	50%	250 €/t [17]	Yield	2,500 €/t [18]	CO_2 absorbed	100 €/t [19]	Value	Yield	35 €/t	
Year 1	70 kg/ tree	4 t/year	**904 €**	0.5 t/ year	**1,250 €**	0.0 t/year	0 €/year	**492 €**	0.20 t/ year	**7 €**	2,161 €
Year 2	80 kg/ tree	4 t/year	**1,033 €**	0.5 t/ year	**1,250 €**	0.6 t/year	57 €/ year	**549 €**	0.25 t/ year	**9 €**	2,349 €
Year 3	90 kg/ tree	5 t/year	**1,163 €**	0.5 t/ year	**1,250 €**	0.8 t/year	80 €/ year	**629 €**	0.30 t/ year	**11 €**	2,503 €
Year 4	110 kg/ tree	6 t/year	**1,421 €**	0.5 t/ year	**1,250 €**	0.9 t/year	94 €/ year	**723 €**	0.35 t/ year	**12 €**	2,778 €
Year 5	140 kg/ tree	7 t/year	**1,808 €**	0.5 t/ year	**1,250 €**	1.5 t/year	150 €/ year	**873 €**	0.40 t/ year	**14 €**	3,222 €

Table № 9: *Potential annual income from food production, biomass and CO_2 credits.*

economic result, which is doubled by the 5th year, and it is expected to increase in the following years.

So, if a company with 6 employees uses electricity in the office and EV vehicles powered with renewable energy, it will need to support and take care for a land plot of 8,200 m² in order to become carbon neutral. The benefits from such cooperation are expressed in Figure 3 and provide more realistic CO_2 measurement practice (case by case).

Conclusion

Reducing GHG emissions should be in place by the time the sustainability of soil health/quality is secured or improved. Therefore, agricultural practices need to be environmentally friendly, without harming directly or indirectly the environment and human health.

	Economic annual balance		
	Income	Expenses	Net
Year 1	2,161 €	1,100 €	**1,061 €**
Year 2	2,349 €	1,100 €	**1,249 €**
Year 3	2,503 €	1,100 €	**1,403 €**
Year 4	2,778 €	1,100 €	**1,678 €**
Year 5	3,222 €	1,100 €	**2,122 €**

Table № 10: *Simple economic balance for land plot of 1,000 m².*

For instance, the application of manure as a soil amendment can be an option for enhancing soil quality and mitigating climate change. However, manure is not everywhere available.

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Company Benefits

- Reduction of the CF of the company
- Income from the food production
- Social cause – donationations of natural food
- Environental education of the teams
- Team building – a place for movement, recreation and entertainment

General Benefits

- Natural and clean food
- Agriculture synchronized with EU targets
- Positive marketing

Farmer Benefits

- Clean soil
- Income from the food production
- Know – How

***Figure 3:** General benefits from cooperation between the Company and the farmer.*

The agriculture also has the potential to help significantly by adapting and mitigate climate change, through practices that help increase soil carbon sequestration, protect carbon sinks and decrease the relative intensity of carbon emissions.

It has to be highlighted that healthy soils have many benefits. The soil is a large carbon sink. The growing of crops that are good for the soil structure may help for additional carbon storage. Diverse cropping systems are better for the soil than monocultures. Minimizing machinery operations can help to avoid soil compaction. Organic practices like no-till and cover cropping reduce CO_2, methane and nitrous oxide emissions. They also help microorganisms turn carbon dioxide into oxygen, and work to reverse climate change by rebuilding soil health. Healthy soil, alive with microorganisms, can store more carbon and improve water filtration leading to cleaner water. Managing weeds and pests without toxic chemicals can be a challenge, but it is possible.

As we can see from the above calculations, the decreasing of energy and fertilizers impact significantly the CO_2 footprint. By using renewable energy for logistics in both company and agroforestry farm activities, reduction of around 40 per cent of the CO_2 footprint would be viable. Moreover, no-till practices and avoiding the use of man-made fertilizers reduce the CO_2 footprint by around 45%. The land use for CO_2 offset is reduced by 34%. The negative impact is in the let's say lower yield. However, it is not about quantity, it's about quality – less food with high quality is better than more food with bad quality.

Why not a cement plant, steel plant, automotive manufacturer, bank, insurance or other company invest or develop "carbon capture agriculture" and benefit from CO_2 emissions trading? Moreover, the food produced in such farms will be natural, and free of man-made chemicals.

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Figure 1: *"Normandy landfill" in the port of Beirut 2004.*

Assessment of Future Market Opportunities for the Use of Lebanese RDF – Project Carried out by MVW Lechtenberg for the UNDP

By Dirk Lechtenberg, MVW Lechtenberg & Partner

In 2022 and 2023 MVW Lechtenberg & Partner was engaged by the UNDP for a detailed study to assess the potential and future market opportunities for refuse derived fuels (RDF) in Lebanon. Before we cater to the outcome of our study, the story of RDF in Lebanon deserves a look back to gain a deeper understanding of the particularities.

A look back - the prequel of RDF in Lebanon

From the moment I visited Lebanon for the first time, I was fascinated by this country. The beautiful nature, wooded mountains, green fields, miles of beaches and secluded bays by the sea. A culture with legacies of different cultures from more than 4000 years; cosmopolitan and friendly people, vibrant cities. I can understand that Beirut has been called the "Paris of the Middle East".

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Now, more than 20 years and certainly umpteen visits later, this country and the will to live - the joie de vivre - of the people fascinates me even more; but now coupled with great sadness about the many disasters of recent years, the sum of which have brought the country to the abyss.

20 years ago, we were tasked with fishing out of the sea and recycling the waste that was simply thrown into the harbour basin and sea during the civil war. The almost 30 m high pile of rubbish was named "Normandy Landfill" because this mountain of rubbish served as a base for the UN peacekeepers.

At that time, we had just started sorting this waste and producing RDF, which was supposed to be used in the "Sibline" cement plant when the belligerent attacks in 2006 reduced the country to rubble. The waste was then taken to a landfill site by the company SOLIDERE – and the site was transformed into Beirut's new marina.

In 2005, we made the first plans to expand the existing waste sorting plants in Karantina and Amrousieh. These were already sorting around 3000 tonnes of household waste per day. According to our plans the non-recyclable materials were supposed to be processed into RDF and used in the three local cement plants as an environmentally friendly substitute for fossil fuels. These plans also came to nothing.

In 2015, a new approach was introduced. The local landfill for Beirut was full, waste was no longer collected, and the city's streets were filled with garbage for months. An intolerable confession hung over the city. At that time, our waste concept was remembered and we were called to solve the waste problem. A plan was drawn up, a budget was drawn up for the expansion of the existing sorting facilities, a new sorting plant was built. "Temporarily" an old landfill (Burj Hammoud) was reopened and simply filled higher up with garbage; a second new landfill, called "Costa Brava", was built into the sea right next to the airport.

The coasts, the sea is full of plastics and waste. Leachate water from the landfill (as well as all other wastewater, e.g., from the metropolis of Beirut) has been discharged untreated into the sea......

When a huge explosion destroyed the port and thus, the country in 2020, the waste management situation was even more catastrophic than ever.

If any waste is collected at all, it will be dumped untreated. Recycling no longer takes place because

Figure 2: *Stacked bales of waste in the sea "Costa Brava".*

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there is no money to run the existing sorting facilities. In rural areas, waste is incinerated in the open air. The environmental situation in Lebanon is catastrophic.

What is the root cause? Corruption!

As in almost all areas of life in Lebanon, corruption dominates waste management considerably. Lebanon's political system is characterized by religious proportional representation and the resulting influence of religions. The current sectarian system causes corrupt sectarian patronage networks that underpins even the most basic administrative functions of the state.

Donor countries that want to support the country are reluctant to continue to let development funds seep into this corrupt system.

Of the 20 sorting plants for waste, more than half are defective. The large sorting plant in Beirut's port "Karantina" was destroyed by the explosion and it is currently being examined whether it can be rebuilt. (4 years after the explosion!).

Back to the present

Currently, around 2 million tonnes of household waste are generated in Lebanon every year, most of which currently ends up in wild landfills. In 2022, our company was commissioned by the UNDP to check the status of the sorting facilities, and to create concepts on how the household waste can be processed, and how to use the non-recyclable waste in the three local cement plants. As in the many approaches since 2004, we have again got in touch with the local cement plants.

In Lebanon, the three major cement plants - Ciment de Sibline SAL-Secil S.A Group, Holcim (Liban) S.A.L.- Chekka, and Cimenterie Nationale (CN) – are potentially significant users of RDF. Currently, these plants rely on fossil fuels for firing their kilns, but they have expressed interest in using RDF as an alternative fuel source. Together, Ciment de Sibline SAL-Secil S.A Group, Holcim (Liban) S.A.L.- Chekka, and CN have a current cement clinker production of around 3.7 million tonnes.

Based on our calculation and considering the current low production of cement clinker, a quantity of up to 390,000 tonnes RDF per year could be consumed. This equals a thermal substitution rate of about 60 per cent. In the long run, with full clinker production capacity, up to 500,000 tonnes of RDF could be absorbed by the local cement industry.

The cement plants would also be willing to pay for a quality-assured alternative fuel. Consequently, the sorting plants could resume their operations.

However, several obstacles prevent these plants from adopting RDF fully. These factors include the absence of a legal framework, low public awareness, unclear regulations and business models, community acceptance, permit issues, and data availability.

Moreover, the cement plants require significant investment to modify their feeding systems and burners to receive RDF continuously, in addition to requesting low-cost RDF compared to petcoke or other fossil fuels. While the Ministry of Environment (MOE) is committed to promoting RDF pro¬duc-tion and use, it is crucial that the government incentivizes potential users to co-process RDF.

These incentives can come in the form of financial support or tax breaks, which would help cement plants to invest in RDF production and retrofit their plants to use RDF. Moreover, raising public awareness about the benefits of RDF and promoting its use as a sustainable fuel source can help overcome community resistance. Ultimately, the government must provide clear and supportive policies to encourage the adoption of RDF by cement plants and promote the growth of a circular economy in Lebanon.

The waste management situation in Lebanon is in a state of crisis, exacerbated by the economic

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downturn, resulting in waste being dumped directly into landfills and dumpsites. Securing funding for all sorting plants across the country is crucial, not only for their renovation but also to prepare them for RDF production. Equally important is ensuring funding for the ongoing operation and maintenance of these plants to prevent future breakdowns. the primary focus is on securing funds for the Beirut plants. Regrettably, the two primary waste treatment facilities in the Beirut area, once operational around the clock and capable of handling approximately 3000 tonnes per day, have ceased functioning effectively. This cessation has significantly worsened the already critical waste disposal problem.

The Karantina sorting plant, requires financial funding for rebuilding and upgrading to resume normal operations and enable RDF production. Additionaly, Amrousieh sorting plant, another major waste treatment facility in Beirut, comprises two plants located in separate buildings, necessitating funding also. The renovation and upgrading of sorting equipment, along with the addition of RDF equipment, are needed for the old plant. Meanwhile, funds are also required for completing the construction of the new building and initiating RDF production at the new plant.

Owing to the municipalities' inability to pay in USD, small waste treatment facilities with capacities ranging from 100 to 150 tonnes per day are mostly not operational, except for two. Additionally, most of these plants lack the expertise and knowledge to produce RDF, and they require investment to acquire the necessary machinery and start RDF production.

The critical need for funding highlights the need for a comprehensive and sustainable waste man-age-ment policy in Lebanon that prioritizes waste reduction, reuse, and recycling. Addressing this issue will require governmental investment and support, public education, and a shift in mindset to view waste as a resource rather than a problem.

In our study for the UN we have provided **recommendations and an action plan for promoting RDF and its implementation in the industry:**

Short-Term Recommendations to Stakeholders

Lebanese Government:

- Pass decree and legislation to organize and legitimize RDF usage as an alternative fuel, aligning with international agreements.
- Initiate an awareness campaign in collaboration with relevant ministries and local stakeholders to promote RDF utilization.
- Implement existing specifications and standards for RDF and emissions as per international best practices.
- Engage local communities and set targeted substitution rates for cement producers to encourage RDF adoption.
- Develop a waste management strategy to minimize landfilling and reduce emissions.

Cement Producers:

- Incorporate RDF pilot runs into cement kilns, monitoring emissions in real-time and showcasing data transparency.
- Integrate RDF into carbon neutrality targets as set by industry associations.
- Undertake CSR initiatives, including awareness campaigns and educational outreach, to support RDF integration.

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Assessment of Future Market Opportunities for the Use of Lebanese RDF – Project Carried out by MVW Lechtenberg for the UNDP

International Organizations:

- Facilitate studies and donations for solid waste management in Lebanon.
- Sponsor awareness campaigns to promote international best practices in waste management.
- Stakeholder Communication Principles
- Clear and unambiguous communication is paramount for effective stakeholder engagement. Key principles include:
- Clarify dialogue expectations and understand stakeholders' motivations.
- Practice honesty and patience, avoiding marketing agendas and defensive attitudes.
- Listen attentively, appreciate diverse perspectives, and select participants carefully.
- Negotiate transparent rules and employ neutral moderators to facilitate constructive dialogue.
- Take time to build trust and understanding, avoiding defensive or dismissive responses.
- Deliver consistent messages without relying on jargon or overly scientific language.

By adhering to these communication principles, stakeholders can stand in productive collaborations and overcome potential misunderstandings.

Long-Term Recommendations

In the pursuit of sustainable waste management practices, long-term strategies are vital. Here are comprehensive recommendations for Lebanon's RDF sector:

Implementation of the "Polluter Pays Principle":

- Introduce a fee collection system targeting waste generators, aligning with international standards.
- Seek international support to establish and maintain the fee collection infrastructure.

Financial Responsibility of Producers:

- Producers pay fees to a designated organization for using packaging marked with the Green Dot symbol.
- Funds collected support waste management and recycling infrastructure.

Funds Allocation:

- Utilize collected fees to enhance waste management infrastructure nationwide.
- Role of Polluters in Waste Management:
- Hold companies accountable for the waste generated by their packaging materials.
- Incentivize the use of recyclable materials and eco-friendly packaging designs.

Consumer Awareness and Participation:

- Educate consumers about the significance of packaging symbols and encourage recycling practices.

Within the next editions of our coprocessing magazine we will update you about what's going on with RDF in Lebanon.

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LINDNER SYSTEMS ENGINEERING

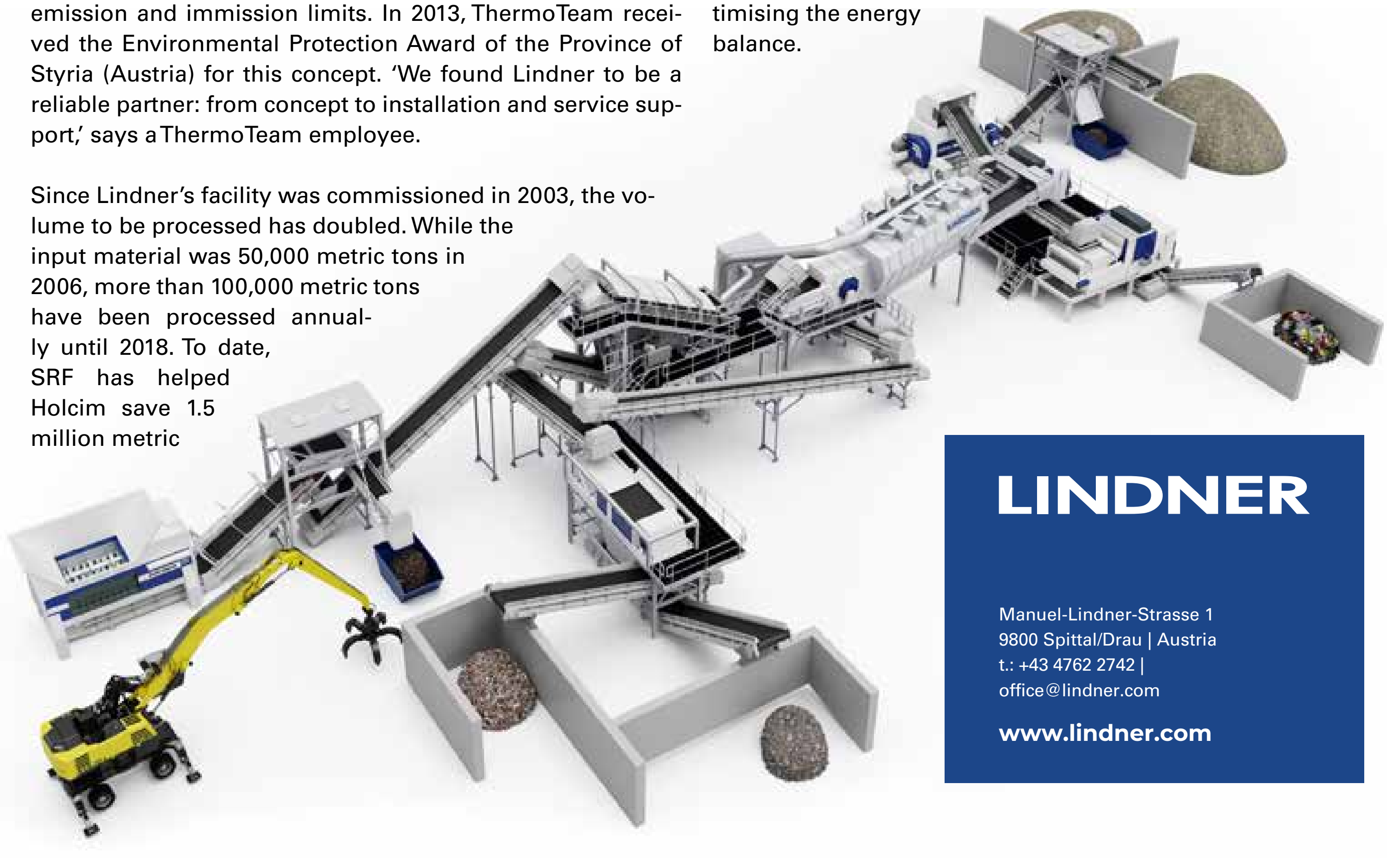
For many decades, high-quality alternative fuels (RDF, SRF) has increasingly replaced fossil fuels such as lignite, oil and natural gas to supply the industry with CO_2-friendly energy. Energy generated by alternative fuel is used to produce electricity and process steam as well as to fuel calciners and main burners e.g. in cement plants in an eco-friendly way. But not all alternative fuels are the same. Cement kilns, in particular, require high-calorific SRF, which has to meet strict specifications in terms of particle size, energy content, density and moisture content. The increasingly high demand for top-quality alternative fuels calls for highly productive solutions and smart RDF and SRF production facilities that additionally extract as much recyclable material as possible and substantially reduce the energy required during production.

The Austrian company ThermoTeam Alternativbrennstoffverwertungs GmbH, a joint venture between Saubermacher and Holcim, formerly Lafarge, is one of the pioneers in the production of alternative fuels, which invested in the future circular economy more than twenty years ago. Lindner Recyclingtech has been on board as a partner from the very beginning and designed the entire line, which was successfully commissioned in 2003. The challenge: unsorted municipal, commercial and industrial waste. The requirement: high-grade, high-energy SRF for the main kiln at the Holcim cement plant in Retznei. The solution: a comprehensive processing facility with special primary and secondary shredders, ferrous and non-ferrous metal separators, and a wind sifter including feeding systems, conveyors and discharge belts. The facility was approved according to the strict criteria of the Austrian Waste Management Act (AWG) to comply with emission and immission limits. In 2013, ThermoTeam received the Environmental Protection Award of the Province of Styria (Austria) for this concept. 'We found Lindner to be a reliable partner: from concept to installation and service support,' says a ThermoTeam employee.

Since Lindner's facility was commissioned in 2003, the volume to be processed has doubled. While the input material was 50,000 metric tons in 2006, more than 100,000 metric tons have been processed annually until 2018. To date, SRF has helped Holcim save 1.5 million metric tons of carbon dioxide (CO_2) just at its cement plant in Retznei in the south of Austria. This corresponds to the amount of CO_2 that an average car would emit while circumnavigating the earth approximately 280,000 times.

In general, waste is much more contaminated these days. According to several studies the lack of correct separation behaviour leads to this increase of problematic materials in waste. Biowaste and organic residues are particularly problematic. Understanding today's challenges, Lindner optimizes it's processing lines to handle such challenges.

Smart, energy-saving and efficient SRF production facilities particularly support the cement industry in increasing high-class output in terms of quality and safety, as well as in achieving its ambitious goals for reducing CO_2 emissions and optimising the energy balance.



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Co-Processing Magazine of Alternative Fuels & Raw Materials

Complimentary Analysis of Carbon Capture and Decarbonizing the Cement Industry

By Kudus Adebayo,
MVW Lechtenberg & Partner

Introduction

The concept of capturing carbon and preventing its release into the atmosphere was first proposed in 1977. However, the technology for capturing CO_2 has been in use since the 1920s, primarily for separating CO_2 found in natural gas reservoirs from usable methane gas. In the early 1970s, CO_2 was captured at a gas processing facility in Texas, USA, and then piped to a nearby oil field where it was used for Enhanced Oil Recovery (EOR). This method has been highly successful, saving millions of tonnes of CO_2 [1].

The recent surge in interest in carbon capture technology has sparked numerous discussions on its development and implementation across various industries. It is crucial to clearly articulate the technology and its potential to reduce CO_2 emissions in energy-intensive industries. In this article, I will give an overview of the carbon capture technology, utilization, and storage, and how CO_2 can be mitigated as well as the complementary impact alternative fuels can contribute towards the net zero goal of the cement industry.

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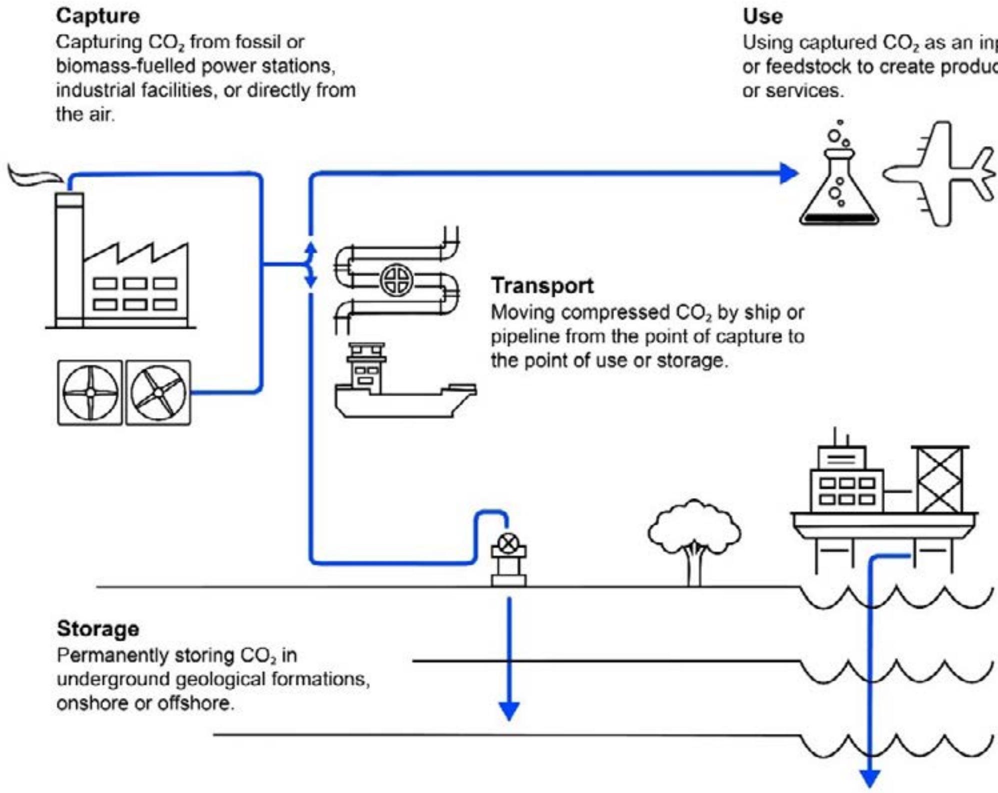

Figure 1: *Illustration of CO_2 capture, usage, and storage [2].*

The International Energy Agency [IEA] describes carbon capture utilization and storage (CCUS) as a suite of technologies that can play a diverse role in meeting global energy and climate goals [2]. As explained above, CCUS involves the capture of CO_2 from large-point sources such as power generation or industrial that utilize fossil fuels or biomass fuels.

CO_2 capturing is normally connected to the industrial production process. It can also be captured directly from the atmosphere. The captured CO_2 is compressed and transported through pipelines, ships, rail or trucks to be stored in deep geological formations that can trap the CO_2 for permanent storage. Such places might be depleted oil and gas reservoirs or saline aquifers [2].

How CCUS Works

The carbon capture utilization and storage technology consists mainly of three steps::

1. Capture
2. Compression and transportation
3. Storage

Capture: It is about capturing of CO_2 at the industrial source by separating CO_2 from other combustion gases. The industrial sources involve high energy-intensive facilities such as coal and natural-gas-fired power plants, steel mills, cement and lime plants, and refineries.

Figure 2 shows a chart of a post-combustion carbon capture technology, called cryogenic carbon-capturing technology. It has been developed by Sustainable Energy Solutions (SES) applicable to cement works, power stations, chemical plants and others. The most common approach is post-combustion absorption which typically uses solvents to separate carbon dioxide out of the flue gas from fossil fuel combustion. Another method includes Pre-Combustion Carbon Capture where, unlike the post-combustion, fuel is gasified to produce a synthesis gas (syngas). A syngas consists mainly of carbon monoxide (CO) and hydrogen (H2). The subsequent shift reaction converts the CO into CO_2, and then a solvent typically separates the CO_2 from H_2 [4].

The key technologic areas of carbon capture are solvents, sorbents, membranes, novel concepts, and hybrids. These key areas serve as a founda-

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tion for the development of technologies for carbon capture and are considered for every technology to be developed and to which industry it will be applied [4].

There are several other CO_2-capturing technologies. Table 1 shows the principal CO_2 capture technologies with an overview and technological status.

Compression and transportation: The next stage is the compression of CO_2 and preparation for transport to the geological storage. There are two main ways to transport CO_2 on a large scale: via pipelines and ships. The most cost-effective method of transporting CO_2 on large scale onshore is via pipelines which have been practiced for a long time. Shipping CO_2 has not been demonstrated yet, but according to the International Energy Agency [IEA], this would be possible and similar to shipping of LPG or LNG.

Using ships, however, offers more flexibility in terms of storage. They could also facilitate the development of CO_2 capture hubs which could later be connected to a permanent pipeline network. Meanwhile, short-distance transportation of small volumes of CO_2 can be carried out by truck or rail, but at a higher cost per tonne of CO_2 [6].

Storage: The storage takes place through the injection of CO_2 into deep underground rock formations or reservoirs of porous rock overlaid with rocks to seal the reservoir and prevent the upward migration or leakage of CO_2 to the atmosphere. Figure 5 shows an illustration of storing CO_2 underground.

There are several types of reservoir storage for CO_2. Two of them having the largest storage capacity include the deep saline formation and depleted oil and gas reservoirs. The CO_2 is trapped through

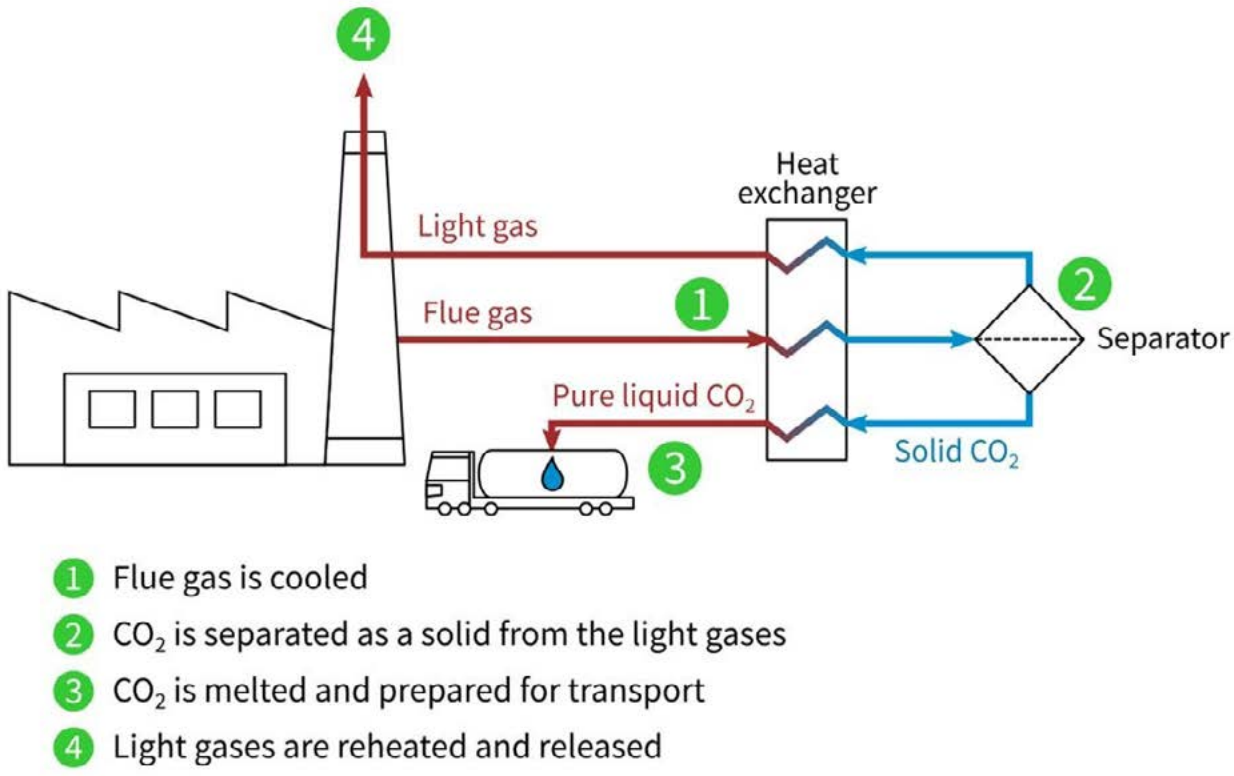

Figure 2: *Cryogenic Carbon Capture Technology for cement industry [5].*

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Capture technology	Overview	Technology status
Chemical absorption	A common process operation based on the reaction between CO_2 and a solvent [such as ethanolamine]. Chemical absorption using amine-based solvents is the most advanced CO_2 separation technique.	Widely used for decades and is currently applied in a number of small and large-scale projects worldwide in power generation, fuel transformation, and industrial production.
Physical separation	Based on either adsorption, absorption, cryogenic separation, or dehydration and compression. Physical adsorption makes use of a solid surface [e.g., activated carbon, alumina, metallic oxides, or zeolites], while physical absorption makes use of a liquid solvent [e.g. Selexol or Rectisol]. After capture by means of an adsorbent, CO_2 is released by increasing temperature [temperature swing adsorption] or pressure [pressure swing adsorption or vacuum swing ad¬sorption].	Currently used mainly in natural gas processing and ethanol, methanol, and hydrogen production, with nine commercial plants in operation.
Oxy-fuel separation	Involves the combustion of fuel using nearly pure oxygen and the subsequent capture of the CO_2 emitted. Because the flue gas is composed almost exclusively of CO_2 and water vapor, the latter can be removed easily by means of dehydration to obtain a high-purity CO_2 stream.	Currently at the large prototype/pre-demonstration stage. A number of projects have been completed in coal-based power generation and in cement production.
Membrane separation	Based on polymeric or inorganic membranes with high CO_2 selectivity, which let CO_2 pass through but act as barriers to retain the other gases in the gas stream.	Technology readiness varies according to fuel and application. Natural gas processing is mainly at the demonstration stage. The only existing large-scale capture plant based on membrane separation is operated by Petrobras in Brazil. Membranes for CO_2 removal from syngas and biogas are already commercially available, while membranes for flue gas treatment are currently under development.
Calcium looping	Involves CO_2 capture at a high temperature using two main reactors. In the first reactor, quicklime [CaO] is used as a sorbent to capture CO_2 from a gas stream to form calcium carbonate [$CaCO_3$]. The $CaCO_3$ is subsequently transported to the second reactor where it is regenerated, resulting in lime and a pure stream of CO_2. The lime is then looped back to the first reactor.	Currently at a pilot / pre-commercial stage. It has been tested for example in coal-fired fluidized bed combustors and cement manufacture
Chemical looping	Like calcium looping, a two-reactor technology. In the first reactor, small particles of metal [e.g., iron or manganese] are used to bind oxygen from the air to form a metal oxide, which is then transported to the second reactor where it reacts with fuel, producing energy and a concentrated stream of CO_2, regenerating the reduced form of the metal. The metal is then looped back to the first reactor.	This technology has been tested through the operation of around 35 pilot projects with coal, gas, oil, and biomass combustion.
Direct separation	Involves the capture of CO_2 process emissions from cement production by indirectly heating the limestone using a special calciner. This technology strips CO_2 directly from the limestone, without mixing it with other combustion gases, thus considerably reducing energy costs related to gas separation.	Currently being tested at pilot projects such as the Low Emissions Intensity Lime and Cement [LEILAC] pilot plant developed by Calix at the HeidelbergCement plant in Lixhe, Belgium.
Supercritical CO_2 power cycles	While in conventional thermal power plants, flue gas or steam is used to drive one or multiple turbines, in supercritical CO_2 power cycles, supercritical CO_2 [i.e., CO_2 above its critical temperature and pressure] is used instead. Supercritical CO_2 turbines typically use nearly pure oxygen to combust the fuel, in order to obtain a flue gas composed of CO_2 and water vapour.	Two prototype/demonstration projects with supercritical CO_2 power cycles are currently in operation: NET Power's Allam cycle and the Trigen Clean Energy Systems [CES] cycle.

Table 1: *Principal CO_2 capture technologies [6].*

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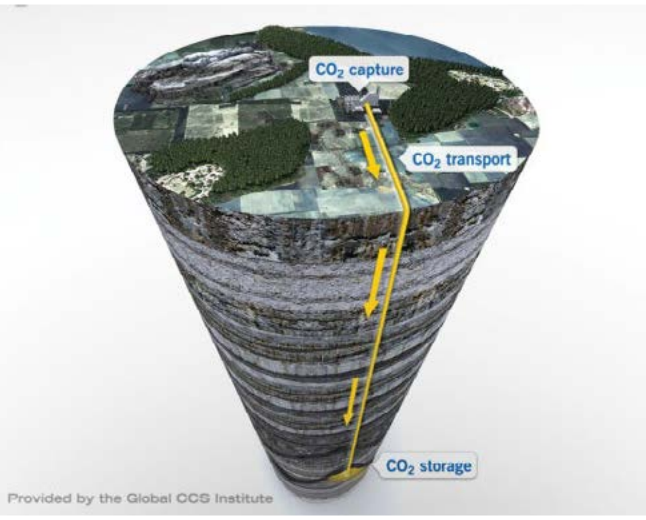


Figure 3: *Illustration of CO_2 storage [7].*

different kinds of mechanisms which are, but are not limited to [6]:

1. Solubility trapping: where the CO_2 dissolves in a brine water
2. Residual trapping: where the CO_2 remains trapped in pore spaces between rocks
3. Structural trapping by the use of a seal
4. Mineral trapping: where the CO_2 reacts with the reservoir rocks to form carbonate minerals.

As far as the storage of CO_2 is concerned, the development of new project lines keeps increasing with connections to pipelines for less cost-effective transportation and storage of CO_2.

Cement Decarbonization, Carbon Capture Technologies, and Alternative Fuels and Raw Materials

The cement industry contributes up to an estimated 7% of total global CO_2 emissions. It is the third largest industrial energy consumer, and, not surprisingly, it is the industry's interest to decarbonize and achieving net zero by 2050.

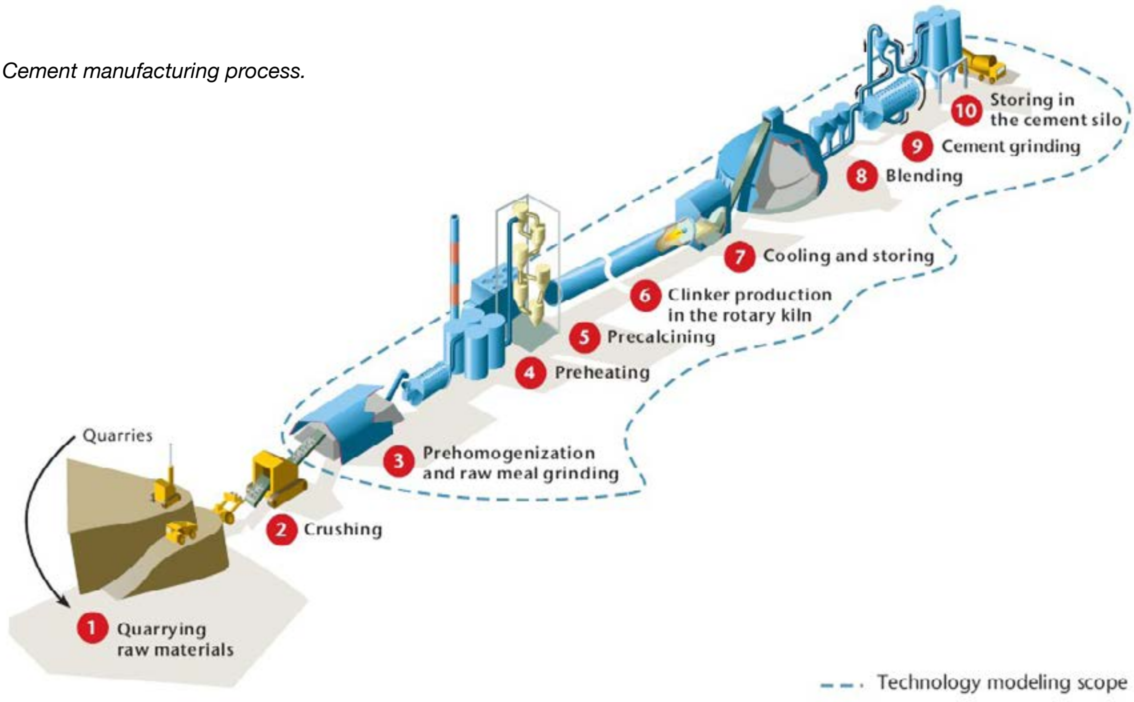
As widely known, around 2/3 of the CO_2 emissions in clinker manufacturing derive from de-carbonisation of the limestone, and 1/3 derive from the fuels (either fossil or waste-derived).

Cement producers have several options to reduce CO_2 emissions in production, including using alternative fuels to fire the kilns, reducing the clinker content in cement, and utilizing carbon capture technologies.

Biomass is an option because it is considered to be carbon neutral. However, the continuous availability is a key factor that cannot be guaranteed in every case.

Besides plastic, refuse-derived fuel (RDF) contains various amounts of biogenic matter. Biogenic matter can consist of paper-based materials, like beverage cartons, packaging, cardboard, waste wood or similar components. The properties of

Figure 4: *Cement manufacturing process.*



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RDF (e.g., calorific value, biomass content) can be controlled by adjusting the recipe in the manufacturing process. The raw material for RDF production is non-hazardous municipal and commercial solid waste. Since the raw material is virtually ubiquitous, the continuous availability may be given, and has an advantage over pure biomass.

But still, both biomass and RDF release CO_2 into the atmosphere.

Recent successful trials with hydrogen indicate a promising way to mitigate fuel-related CO_2 emissions [9]. However, only "green" hydrogen is the key to mitigate fuel-related CO_2 emissions completely [3].

CO_2 emissions from the raw material cannot be avoided, for limestone is the basic material for clinker. Reducing the clinker content in cement grinding is considered the most effective way to reduce CO_2. So-called SCMs [supplementary cementitious materials] can substitute significant amounts of clinker in cement. SCMs include granulated blast furnace slag, pulverized fly ash, or natural pozzolan. The substitution of clinker would affect both sources of CO_2 while the other methods majorly affect the fuel combustion part which only comprises 30 – 40% of the CO_2 emission in cement production [10].

However, standards and regulations governing cement production do not necessarily allow larger clinker substitution considering the risk associated with a low-quality concrete application in construction. Cement is the most widely used building material. It is estimated that considering the increase in global population and the need for infrastructural development, the demand for cement will increase up to 12-23 % by 2050. Along with that, a 4% increase in direct CO_2 emissions from the cement industry is expected under the IEA's Reference Technology Scenario [RTS] [14].

CEMBUREAU's roadmap for the cement industry to achieve climate neutrality by the year 2050 points to the following measures: the use of decarbonated raw materials, biomass, improvement in

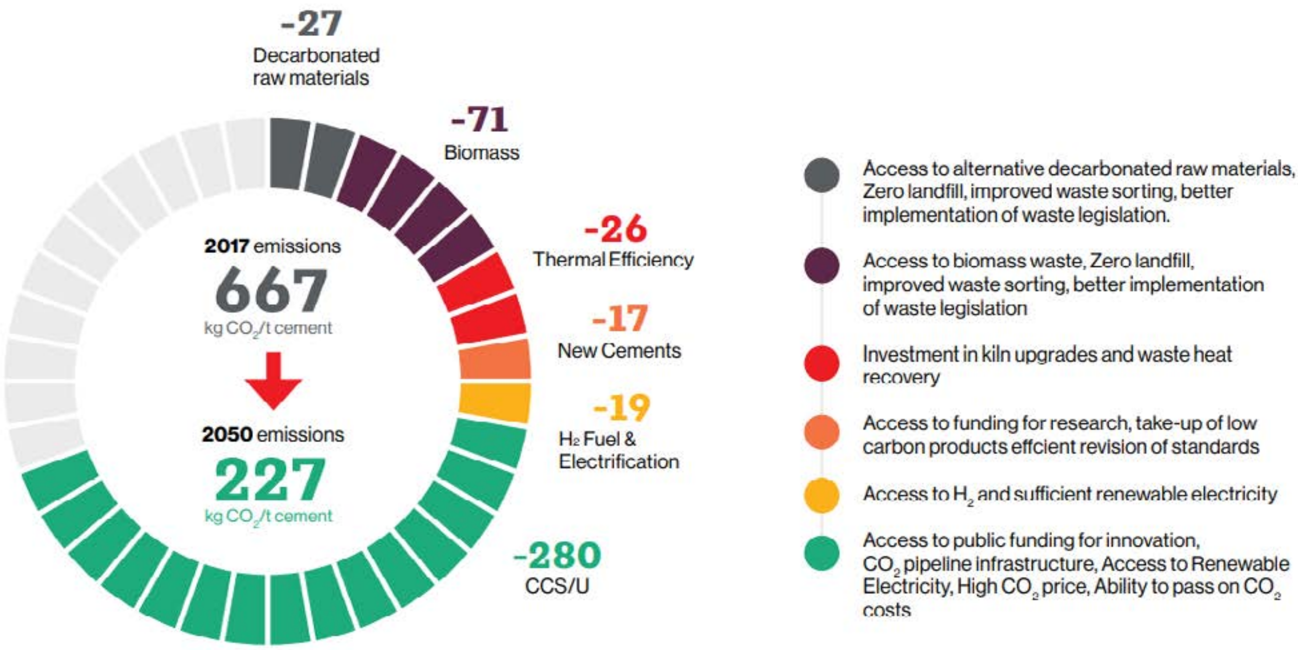

Figure 6: *Roadmap to $C0_2$ reduction in cement manufacturing [11].*

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thermal efficiency, new cement with fewer clinker contents, H_2 fuel electrification, and carbon capture technology [11].

The roadmap targets up to a 3.5 per cent reduction of process CO_2 using decarbonated materials by 2030 and up to an 8 per cent reduction by the year 2050. The roadmap also points to the important usage of alternative fuels. In 2017, alternative fuels use represented 46 per cent of the total needs in kilns across Europe and in fact, there are no impediments to a 90 per cent usage of alternative fuels if the materials are locally available. By 2030, 60 per cent of alternative fuels containing 30% biomass shall be achieved. The target for 2050 is even more ambitious: 90 per cent of alternative fuels with 50 per cent biomass [11].

Cement production is expected to keep rising, but measures to reduce CO_2 emissions must also increase to achieve the roadmap's vision. It is estimated that the use of carbon capture technology will reduce CO_2 emissions by 42% in 2050. Moreover, it is expected that a further decrease in clinker-to-cement ratio to 0.65 by 2050 can be achieved. Figure 6 highlights the roadmap.

Decarbonizing the cement industry seems like an impossible mission considering the complexity it involves. The complexity stems from the years in the usage of cement and customers' expectations of cement performances, the market, the regulations, requirements, and standards of production. Furthermore, availability of SCMs is decisive, and, last but not least, the cement market which is also playing a role in the decisions of a cement manufacturer. However, the available technology and approaches of the CO_2 reduction levers have also proven that decarbonization is indeed possible.

Let's examine the approaches in contexts to get more understanding of the available technologies and methods. As mentioned earlier, reducing the clinker content in cement is the most efficient and cost-effective short-term strategy to decarbonise cement manufacture, because it addresses both segments of the carbon dioxide in clinker: The CO_2 from combustion of the fuels to fire the kiln and the CO_2 from calcination of the calcium carbonate, $CaCO_3$, in the kiln feed which produces the lime, CaO, needed to form the clinker minerals. The CO_2 is only associated with the clinker so the less clinker in the cement the less CO_2 associated with the manufacture of the cement. The clinker is substituted with other supplementary cementitious materials (SCMs) such as granulated blastfurnace slag, pulverised fly ash or natural pozzolan, or with fillers such as limestone. This is also the most popular strategy because it reduces the costs of cement manufacture and increases the volume of cement that can be produced and sold from a fixed volume of clinker. Both of these boost the profitability of the cement company producing the cement. These are major incentives for cement companies to reduce the clinker content of the cements they produce, besides the reduction in the CO_2 with the cement [10].

However, this strategy is constrained by the requirement to meet pertinent standards and specifications for the cements produced and sold. A further constraint on the amount by which the clinker content of cement can be reduced is that the cement standards often specify a minimum clinker content below which the clinker content cannot be reduced. For instance, the European Standard EN 197 sets specific limits on minimum clinker content, setting time and compressive strengths for blended cements [13]. It is well known that if the clinker content of the cement is reduced, the hydraulic reactions are diluted and the compressive strength developed by the mortars and concretes is lower, particularly at early ages of the mortar or concrete at 1-day, 7-days and 28-days. Moreover, the perception of customers has to be considered. We know from our projects that sometimes customers conclude that the cement is of good quality only on the basis of its dark colour. The more clinker it contains, the better it's quality.

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Project name	Cement producer	Location	Technology	Expected capture capacity (tpa)	Completion (est)
Concrete Chemicals	CEMEX	Rüdersdorf, Germany	Post-combustion	N/A	2026
Edmonton	Heidelberg Materials	Edmonton, Canada	Post-combustion	1,000,000	2026
Höver	Holcim	Höver, Germany	Post combustion	1,300,000	2026
ANRAV	Heidelberg Materials	Devnya, Bulgaria	Post-combustion	800,000	2028
KOdeCO net zero	Holcim	Koromacno, Croatia	Post-combustion	N/A	2028
Carbon2Business	Holcim	Lägerdorf, Germany	Oxyfuel	N/A	2029
GeZero	Heidelberg Materials	North Rhine-Westphalia, Germany	Oxyfuel	700,000	2029
Slite	Heidelberg Materials	Slite, Sweden	Post-combustion	1,800,000	2030
C2PAT	Holcim	Mannersdorf, Austria	Post-combustion	700,000	2030
Aalborg onshore	Aalborg Portland	Aalborg, Denmark	N/A	400,000	2030
Peak Cluster	Aggregate Industries	Peak District, UK	N/A	N/A	2030
Exshaw	Holcim	Exshaw, Canada	N/A	N/A	2030
K6	CRH (Eqiom)	Lumbres, France	Oxyfuel	800,000	2037
CO2NTESSA	NEXE dd	Nasice, Croatia	Oxyfuel	700,000	N/A
Victorville	CEMEX	Victorville, USA	Post-combustion	N/A	N/A
Balcones	CEMEX	Balcones, USA	Post-combustion	N/A	N/A
Lighthouse'ECCO2	Holcim	Carboneras, Spain	Post-combustion	700,000	N/A
Baimashaun	Anhui Conch	Baimashaun, China	Post-combustion	50,000	N/A
Heping	Taiwan Cement	Heping. Taiwan	Calcium looping	N/A	N/A
Tamil Nadu	Dalmia Cement	Ariyalur, India	Post-combustion	500,000	N/A
Go4ECOplanet	Holcim	Kujawy, Poland	Post-combustion	N/A	N/A
Mitchell K4	Heidelberg Materials	Mitchell, USA	N/A	2,000,000	N/A
Anthemis	Heidelberg Materials	Antoing, Belgium	Oxyfuel & amine	800,000	N/A
Berrima	Borat	New South Wales, Australia	Direct separation	100,000	N/A
IFESTOS	Titan Cement	Kamari, Greece	Oxyfuel & post-combustion	1,900,000	N/A
China United Qingzhou	China United Cement Group	Shandong, China	Oxyfuel & post-combustion	200,000	N/A

Table 2: *CCUS projects scheduled to be finished after 2026 [12]*

To ensure the practicality of cement, its usage in concrete projects and customer confidence in the product must also be taken into account. While blended cement has a low clinker content, its applicability to certain concrete projects could be limited. To address this, the cement industry has developed a broad range of various types of cement. For instance, CEM II B cements comprise Portland cement clinker and gypsum (Portland cement), and up to 35 per cent of other single constituents like

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blast furnace slag, pozzolan or fly ashes. Effectively this sets the minimum clinker content of a CEM II B cement to 60 per cent, irrespective of the strength class of the cement (the remaining 5 per cent is attributed to gypsum). CEM III cements comprise Portland cement clinker and gypsum (Portland cement), and more than 35 per cent of blastfurnace slag. CEM IV cements comprise Portland cement clinker and gypsum (Portland cement), and more than 35 per cent of pozzolana. CEM V cements comprise Portland cement clinker and gypsum (Portland cement), and more than 31 per cent of each of blastfurnace slag and pozzolana. Production of such CEM III, IV or V cements is therefore a means to reducing the clinker content of cement well below 60 per cent [10].

The carbon capture technology is slowly being adopted in cement plants and is expected to be standard practice by 2030. However, considering the amount of cost and equipment needed for the establishment of the technology, the cement industry is way behind. According to the IEA roadmap for the cement industry, a lot of CO_2 has to be captured, used, or stored. To achieve the net zero goals, an estimated 552 $Mtco_2$ per year must be mitigated. Evidently, the 2030 objective of the cement industry may be running too slow, hence the need to complement the CCUS technology with an alternative energy source. In the next table shows compilation of several carbon capture projects either already in progress or anticipated to commence operations in 2024/25.

The integration of technologies and approaches like carbon capture technologies, reduction in clinker content, and alternative fuels would be the best possible solution to achieving the net zero goals of the cement industry. It can be concluded that the cement industry may not be capable of achieving net-zero emissions by 2050. However, with the implementation of existing policies and efforts, it is anticipated that emissions from the cement industry will decrease by 75% in 2050 as compared to the emission rate in 2017.

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Lafarge Africa Cuts Carbon Emissions Through Alternative Fuel Usage

Lafarge Africa has announced a significant reduction in carbon emissions from its manufacturing activities by utilizing alternative fuels and energy-efficient technologies. According to the CEO, Lolu Alade-Akinyemi, CO_2 emissions dropped from 595 $kgCO_2$ /t in 2021 to 574 $kgCO_2$ /t in 2022, with a global thermal substitution rate of 13.5%. The company's sustainability efforts include quarry rehabilitation, biodiversity restoration, and community engagement for sustainable livelihoods. Recognized for its commitment to international standards, Lafarge Africa received the prestigious 2022 NGX Made of Africa Award for Sustainability Reporting.

Source: https://www.thisdaylive.com/index.php/2023/11/09/lafarge-africa-reduces-carbon-emission-by-using-alternative-fuel

Nigeria

Nigerian Businesses Shift to Local Raw Materials Amid Forex Scarcity

As the scarcity of foreign exchange worsens in Nigeria, many businesses are turning to local raw materials to cut costs and navigate the challenging economic environment. The forex crisis, exacerbated by recent changes in exchange rate calculation methodology, has led to a depreciation of the naira against the dollar by over 50%.

With limited access to foreign currencies at official rates, businesses reliant on imported components are facing significant challenges. Industries such as agro-allied, construction, cement manufacturing, and consumer goods production are particularly affected.

One prominent example is the BUA Group, which has transitioned its cement plants and sugar refinery to locally sourced coal and liquefied natural gas for energy needs, saving millions of naira daily. Other major players like Lafarge and Dangote Cement are also reducing reliance on imported fuels, opting for locally mined coal and investing in alternative fuels like Compressed Natural Gas (CNG).

This shift underscores businesses' resilience in adapting to forex liquidity constraints and underscores the importance of domestic resource utilization for sustainability in Nigeria's economic landscape.

Source: https://hallmarknews.com/manufacturers-businesses-adopt-backward-integration/

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India

Report Highlights Carbon Abatement Measures in Indian Cement Industry

A recent report by Council on Energy, Environment and Water from India has analyzed carbon abatement measures aimed at achieving net zero emissions in India's cement industry. The report includes a Marginal Abatement Cost (MAC) curve for existing plants nationwide, showcasing the cost-effectiveness of various carbon mitigation technologies.

The analyzed measures fall into four categories: Energy Efficiency (EE), use of Alternative Fuels and Raw Materials (AFR), adoption of Renewable Energy and alternative fuels like biomass and municipal solid waste, and Clinker Factor Reduction (CF), along with carbon management solutions.

India, as the second-largest cement producer globally, is witnessing a surge in infrastructure development, further driving cement demand. The Indian cement sector has been proactive in implementing efficiency measures and setting ambitious net-zero targets, with initiatives like the Perform, Achieve and Trade (PAT) scheme contributing to the adoption of energy-efficient technologies.

However, to align with India's climate goals and meet the increasing demand, a broader approach beyond energy efficiency is essential, the report emphasizes. This comprehensive analysis underscores the industry's commitment to sustainability and its pivotal role in India's transition towards a low-carbon future.

Source: https://www.hindustantimes.com/ht-insight/climate-change/evaluating-net-zero-for-the-indian-cement-industry-101708771129128.html

India

India Cements Ltd. Reports Loss Amid Construction Slowdown

India Cements Ltd. faced challenges in the third quarter, recording a loss of 165.1 million rupees ($2 million) compared to a profit of 907.3 million rupees last year. The southern India-focused cement maker cited subdued demand due to reduced construction activity before elections and cyclones in certain states.

The company, a key player in southern India, experienced a slowdown in construction due to elections in Telangana and cyclones in Tamil Nadu and parts of Telangana. Additionally, a moderated demand during the festival season contributed to the loss.

Analysts observed that average cement prices remained stable during the quarter, as weak volumes prompted cement companies to retract price increases.

In contrast, larger competitors like UltraTech Cement, ACC , and Dalmia Bharat reported significant profit growth driven by robust infrastructure demand.

Source: https://www.reuters.com/markets/commodities/india-cements-reports-third-quarter-loss-subdued-demand-2024-02-01/

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Japan

SM Prime Joins Forces with GUUN Co. Ltd to Revolutionize Waste Management

SM Prime, a leading property developer in the Philippines, has teamed up with GUUN Co. Ltd, a Japanese company specializing in material recovery and recycling, to establish a joint venture aimed at transforming waste management practices in the country.

In this partnership, SM Prime holds 70% of the equity in the Philippine joint venture company. GUUN, known for its innovative production of alternative fuels from non-recyclable waste materials, brings its expertise to the table.

The joint venture aims to develop infrastructure for systematic waste management and resource recovery, following the successful practices of Japan. This initiative aligns with SM Prime's commitment to reducing landfill impact and promoting sustainable development.

GUUN's groundbreaking "fluff fuel" is derived from non-recyclable waste and serves as an eco-friendly alternative to solid fossil fuels like coal. It is utilized in cement kilns, industrial boilers, paper manufacturing, and power plants, effectively reducing waste buildup while creating opportunities for waste pickers to become formal waste sorters.

Hans Sy, Chairman of the Executive Committee at SM Prime, expressed enthusiasm for the partnership, highlighting its potential to benefit local communities and bridge the gap between society and the environment.

GUUN's CEO, Shinji Fujieda, affirmed their dedication to contributing significantly to the Philippines' resource circulation system, expressing confidence in the partnership's success.

The Department of Environment and Natural Resources (DENR) Secretary, Toni Yulo-Loyzaga, emphasized the importance of such collaborations in advancing sustainable waste management practices, underscoring the role of partnerships like SM Prime and GUUN in shaping a sustainable future for the country.

Source: https://business.inquirer.net/444377/fueling-the-future-sm-prime-unveils-groundbreaking-waste-to-fuel-partnership

SM Prime joins forces with GUUN to develop infrastructure for waste management, aiming to minimize landfill impact across SM Prime and non-SM Prime properties.

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Malaysia

Prime Integrated Waste Solutions Inc. (PWS) Introduces Low-carbon RDF Supply

PWS has launched the supply of low-carbon refuse-derived fuel (RDF) from processed municipal solid waste. This move is part of PWS' strategy to add value to waste and reduce landfill waste significantly.

Operating in Cebu, PWS processes 1,000 tonnes of municipal solid waste daily. The facility segregates waste, extracting recyclables and producing RDF material. Plans are underway to increase RDF production to 100 tonnes per day.

Supported by Prime Infra, PWS aims to convert recovered resources into sustainable fuels. The initiative aligns with Prime Infra's commitment to sustainability, led by Filipino businessman Enrique K. Razon Jr.

Source: https://cebudailynews.inquirer.net/535233/prime-infra-waste-unit-starts-production-of-low-carbon-rdf-in-cebu

A worker at PWS facility.

Philippines

Dagupan City Partners with Holcim to Convert Waste to Energy

Dagupan City has teamed up with Holcim Philippines to address solid waste management issues by implementing cement kiln co-processing. Mayor Belen Fernandez announced that Holcim will convert plastic and rubber waste into alternative energy and raw materials for cement production.

Co-processing, a government-approved technology, transforms waste into low-carbon fuels and raw materials, preventing harmful gas formation. The initiative targets processing 40 tonnes of waste at the city's dumpsite, reducing operational costs.

Holcim will supply cement in exchange for waste processing services. Mayor Fernandez highlighted long-term benefits, including plans to transform areas like Bonuan into tourism destinations.

The closure of the old dumpsite in compliance with environmental regulations underscores Dagupan's commitment to sustainable waste management.

Source: https://www.pna.gov.ph/articles/1218939

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Asia

Thailand

Insee Ecocycle Advocates Proper Waste Management for Circular Economy in Thailand

Insee Ecocycle, a sustainable solution provider, emphasizes the importance of managing industrial and community waste effectively to drive Thailand's circular economy. CEO Suchintana Viraratt highlights solutions such as plastic recycling and producing refuse-derived fuel (RDF) for electricity and cement production.

Viraratt underscores the challenge posed by improper waste sorting in communities, leading to increased waste management costs. Proper sorting, she notes, enables recycling, with community waste being suitable for RDF production, consisting of 80% plastic waste.

Emphasizing the symbiotic relationship between the circular economy and waste management, Viraratt expects Insee Ecocycle to reduce 300,000 tonnes of industrial and community waste this year. The company aims to enhance efficiency by exploring alternatives like increasing RDF production.

Viraratt views waste as a valuable resource to be managed throughout the production process for maximum benefit. According to the Pollution Control Department, Thailand generated 25.70 million tonnes of waste last year, with efforts underway to properly manage and utilize this resource.

Source: https://www.nationthailand.com/thailand/general/40033172

Turkey

Limak Çimento Sanayi ve Ticaret A.Ş. Contracts Another HOTDISC® Reactor for Decarbonization Efforts

In a significant move towards decarbonization, Turkish cement manufacturer Limak Çimento Sanayi ve Ticaret A.Ş. has partnered with us to procure a HOTDISC® Reactor for its 5000 tpd line at the Kilis plant. This innovative technology will supply the In-Line Calciner with shredded tires, replacing a substantial portion of lignite and resulting in a remarkable reduction of greenhouse gas emissions by at least 80%. Contracts were finalized in March, with the system's commissioning scheduled for 2025. This collaboration underscores our commitment to supporting ambitious cement manufacturers in their journey towards achieving Net Zero emissions. As the cement industry transitions away from fossil fuels, the HOTDISC Reactor plays a pivotal role in maximizing the calorific value obtained from waste and alternative fuels. With numerous successful installations worldwide, including three in Turkey, this order marks a significant step forward in advancing sustainable practices within the cement industry.

Source: https://www.linkedin.com/posts/flsmidth-cement_order-announcement-another-hotdisc-activity-7194317330980454400-UIOW?utm_source=share&utm_medium=member_desktop

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Europe

France

EQIOM and Air Liquide Partnered for Carbon Capture, Utilisation and Storage (CCUS) Project

EQIOM and Air Liquide have announced a collaboration project named "K6" aimed at transforming EQIOM's Lumbres plant into one of Europe's first carbon-neutral cement plants as per EQUIOM and Air Liquide joint press release. The project, funded by the European Commission's Innovation Fund, plans to capture approximately 8 million tonnes of CO_2 over the initial decade of operation.

As part of the K6 project, EQIOM will undertake technological innovations and extensive modifications to its Lumbres plant in France. This includes implementing an oxyfuel-ready kiln powered by alternative fuel. Air Liquide will support the initiative by supplying oxygen and employing its CryocapTM Oxy technology to capture and liquefy CO_2 emissions.

The captured CO_2 will either be transported to storage sites beneath the North Sea or utilized in building materials. Situated near the port of Dunkirk, the project aims to foster a new carbon capture and storage ecosystem in Europe.

Roberto Huet, EQIOM CEO, expressed gratitude for EU and French government support, highlighting the project's contribution to carbon neutrality and sustainable development. Pascal Vinet, Senior Vice President of Air Liquide, noted the significance of the project in decarbonizing industrial activities and aligning with sustainability objectives.

The K6 project represents a crucial step towards reducing emissions in the cement industry and advancing Europe's transition to a low-carbon economy.

Source: https://www.eqiom.com/actus/eqiom-and-air-liquide-project-northern-france-selected-european-innovation-fund-010422

Spain

Prezero to Supply Refuse Derived Fuel to Cemex in Spain

Prezero, a waste management group, has struck a deal with Cemex in Spain to provide RDF for cement production. The aim is to boost Cemex's use of alternative fuels, with Prezero investing over €20m to expand its facilities in Barcelona. Starting October 2024, the enhanced processing plant will handle up to 190,000 tonnes of industrial waste annually, supporting Cemex's sustainability goals. The collaboration also includes joint efforts to explore innovations for reducing the carbon footprint of cement production. Cemex, committed to achieving net zero emissions by 2050, views this partnership as a significant step toward its decarbonization strategy.

Source: https://www.euwid-recycling.com/news/business/prezero-to-supply-rdf-to-cemex-plants-in-spain-281123/

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Europe

Netherlands

Pryme N.V. Achieves Milestone with Production of 30 Tonnes of Pyrolysis Oil:

Pryme N.V., a pioneering cleantech company from the Netherlands, has reached a significant milestone by producing 30 tonnes of pyrolysis oil, marking a crucial advancement in its efforts to establish a low-carbon circular plastic economy. Building upon earlier successes, including the initiation of commercial production in April 2024, Pryme converted over 25 tonnes of plastic waste into 20 tonnes of pyrolysis oil during continuous production periods. These achievements validate the efficiency and scalability of Pryme's technology, as evidenced by the smooth flow of feedstock, normal operating pressures, and the effective performance of its electrically heated reactor. Karel Kraanen, Pryme's Production Manager, emphasized the emotional significance of these accomplishments, highlighting the company's commitment to sustainability. With regulatory approvals pending, Pryme anticipates shipping its product to its first customer in May, while management projects to produce at least 500 tonnes of pyrolysis oil in Q2-2024, furthering its mission to revolutionize plastic waste management.

Source: https://newsweb.oslobors.no/message/616911

Ukraine

Waste Turned into Fuel for Zhytomyr Cement Plants

Waste recycling plant in Zhytomyr is converting up to 15 tonnes of municipal waste per hour into RDF for three cement plants: Kamianets-Podilskyi, Ivano-Frankivsk, and Zdolbuniv. The plant, funded by a private investment of 12 million euros, has been operational since February 2023 and is currently in its testing phase. It aims to enhance its processing capacity to 20-22 tonnes of MSW per hour with the installation of additional equipment.

The plant boasts advanced sorting capabilities, processing 10 types of high-quality recyclables, including PET bottles, glass cullet, and aluminium cans. Despite facing challenges such as lacking necessary Ukrainian State Standards (DSTU) and environmental approvals, the plant is looking to expand its production by introducing plastic and wood recycling lines by the end of the year. Pavlo Furman, the company's chief engineer, highlighted plans to modernize and increase capacity to meet the growing waste management needs of Zhytomyr.

Source:https://ecopolitic.com.ua/en/news/u-zhitomiri-smittya-peretvorjujut-na-palivo-dlya-troh-cementnih-zavodiv-2/

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Europe

UK

Cemex and MPA Lead UK Cement Industry`s Decarbonization Efforts

In a bid to revolutionize the cement industry's environmental impact, companies like Cemex and associations like the Mineral Products Association (MPA) are at the forefront of decarbonization efforts in the UK. Despite challenges such as isolation from industrial clusters, these pioneers are forging ahead with innovative solutions and government support to steer the sector towards a sustainable future.

The journey is particularly arduous for plants like Rugby's Cement Works, operated by Cemex, which are situated away from industrial hubs. However, the commitment to decarbonization remains unwavering. Cemex's investments in alternative fuels and the MPA's advocacy for supportive policies are key pillars in this endeavor. Despite the challenges, the potential benefits, including CO_2-derived concrete and the introduction of a Carbon Border Adjustment Mechanism (CBAM), offer a promising outlook for a net-zero future. As Cemex and the MPA lead the charge, their journey serves as a beacon of hope, illustrating the transformative power of collaboration and innovation in achieving sustainability goals.

Source: https://bnnbreaking.com/sustainability/pioneering-the-future-the-quest-for-net-zero-at-rugbys-cement-works

Middle East

Kingdom of Saudi Arabia

City Cement Co. Braces for 8% Rise in Costs Amid Fuel Price Surge

City Cement Co. anticipates an 8% increase in total costs following the recent surge in fuel prices, as announced by Saudi Aramco. The cement producer disclosed in a statement to Tadawul that its proactive investments in alternative fuel and waste heat recovery systems have partially mitigated the financial impact of the price hike. However, the company emphasized its ongoing efforts to further minimize the repercussions of escalating fuel prices.

The forthcoming financial statements from Q1 2024 are expected to reflect the impact of these developments, according to City Cement Co. In January, the company had previously announced receiving a notification from Saudi Aramco regarding adjustments to fuel product prices utilized in cement production, effective from January 1, 2024, as reported by Argaam.

Source: https://www.argaam.com/en/article/articledetail/id/1707649

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Kingdom of Saudi Arabia

Prince Abdulaziz Affirms Oil`s Vital Role in Global Energy Landscape Amid Saudi Arabia`s Push for Sustainable Future

In a recent interview with the Saudi Association for Energy Economics (SAEE), Saudi Arabia's Minister of Energy, Prince Abdulaziz bin Salman, emphasized the enduring importance of oil as a vital global energy source. Prince Abdulaziz highlighted expert assessments indicating the sustained growth of oil demand in the medium and long term. He underscored that despite shifts in the energy landscape, oil will remain a cornerstone of the world economy's growth trajectory. Prince Abdulaziz also noted the resilience of OPEC+ in navigating market challenges, reinforcing its role in ensuring stability.

Moreover, Prince Abdulaziz outlined Saudi Arabia's strategic initiatives towards a future of sustainable energy. The Kingdom is actively diversifying its energy portfolio, investing in renewable sources like solar, wind, and clean hydrogen, alongside traditional fuels. Notably, plans are underway to construct the world's largest green hydrogen plant in NEOM mega city by 2026, marking a significant leap in clean energy production. With ambitious targets to increase renewable energy capacity and reduce carbon emissions, Saudi Arabia is positioning itself as a leader in fostering a sustainable and clean energy future.

Source: https://www.argaam.com/en/article/articledetail/id/1708606

UAE

Thyssenkrupp Polysius and Fujairah Cement Industries Signed MoU for Sustainable Cement Production

In a significant move at COP28 in Dubai, thyssenkrupp Polysius GmbH and Fujairah Cement Industries (FCI) have joined forces to address the pressing issue of CO_2 emissions in cement manufacturing. Under this partnership, thyssenkrupp's prepol® SC will be deployed to explore alternative fuel options, thereby aiming to reduce operational costs and mitigate environmental impact.

With a focus on enhancing energy efficiency and resource conservation, this collaboration signifies a commitment to greener practices in the cement industry. By leveraging thyssenkrupp's expertise and innovative solutions, such as the prepol® SC combustion chamber, both companies are poised to pioneer sustainable approaches in cement production.

This alliance not only demonstrates a proactive stance towards environmental stewardship but also underscores the potential for industry-wide transformation towards more eco-friendly practices. As global efforts intensify to combat climate change, partnerships like these play a crucial role in driving tangible progress towards a more sustainable future.

Source: https://insights.thyssenkrupp-polysius.com/news/thyssenkrupp-polysius-and-fujairah-cement-industries-cooperate-on-decarbonization-of-cement-producti/

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