TRADE & INDUSTRIAL POLICY STRATEGIES

INDUSTRIAL DEVELOPMENT PROJECTS

ALTERNATIVE FUEL

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A contribution to South Africa's Post COVID-19 Recovery Plan: Tapping into new and unmet sources of demand to support the establishment of new companies, factories, value chains and employment opportunities

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INTRODUCTION

As South Africa responds to COVID-19 and aims to stimulate the economy and job creation post lockdown, an opportunity should not be missed to consider investing in new product markets which could increase the size and dynamism of the manufacturing sector. Such a package could contribute to arresting the current trend of deindustrialisation and shift the trajectory of the industrial base into new, sustainable growth areas and value chains. This would result in new factories, new downstream demand for primary and intermediate inputs, new export products, increased foreign exchange earnings, and importantly new direct and indirect long-term jobs.

Using the idea of "business *un*usual" TIPS economists have put together a Post COVID-19 recovery programme in South Africa that could provide the impetus to arrest the current trend of deindustrialisation and herald in the beginning of a new generation of industrial activity.

Seven initial projects have been identified. They represent a wide array of economic activity in the special purpose machinery, agro-industries, bioplastics, shipping, alternative fuel, biochemicals and automotive component manufacturing sectors.

This project looks at establishing a co-processing facility at a cement plant as a means to catalyse a broader waste beneficiation industry in South Africa.

For more information on this or other projects please contact Sandy Lowitt at 082 373 1150.

ALTERNATIVE FUEL

PROJECT SUMMARY SHEET

TITLE	Establishing a co-processing facility at a cement plant as a means to catalyse a broader waste beneficiation industry In South Africa.
LEAD DEPARTMENT	Department of Trade, Industry and Competition. Other Departments: Department of Science and Innovation and Department of Environment, Forestry and Fisheries
PROJECT SUMMARY	To build a co-processing facility at a cement plant. The plant will receive non-hazardous general industrial waste and will process the waste on site (sorting, screening, shredding, drying, grinding, mixing, testing/analysing) into a homogenous alternate fuel which can be used as a substitute for coal in the cement plant's kiln, pre-heating chamber or pre-calciner. The alternate fuel will also be a source of substitute raw materials needed in the production of clinker. Co-processing must comply with the strict end user requirements of the fuel, specifically the fuels calorific content and chemical composition.
APPROXIMATE BUDGET	R30 million to R35 million.
STAKEHOLDERS	• A cement company which will sign an offtake agreement (in principle one has agreed to participate). • An established large waste collection company to provide reliable feedstock (only one existing waste company has experience in RDF (refuse derived fuel) and should be approached). • A co-processing technical operator familiar with the chemical and thermal requirements of cement plants and some knowledge of waste regulations and policies (an individual with relevant skills and connections has been identified through the Association of Cementitious Material Products). • A black industrialist to build and operate the company.
CAPITAL INVESTMENT	• Physical infrastructure, building, utilities, docking station. • Capital equipment: shredders, separators, conveyor belts, grinders, mixers, balers/shapers, trucks, fuel injection system. • Laboratory equipment: services can be in house or can be outsourced.
OUTCOMES	• Job creation: eight to 10 employees at processing plant; 30 to 40 employees at waste collection facility; two or three laboratory jobs; temporary construction jobs and engineering jobs to produce and maintain the feeder system. As all cement plants are located in rural areas adjacent to limestone quarries processing plant jobs will be created in areas where there are currently limited economic opportunities. • Decrease carbon footprint of cement industry and a contribution to the GHG commitments made by the National government, decreased amount of waste being land filled • Most importantly – a strategic intervention to start creating waste value chains that are able to valorise waste and allow beneficiation. The project will be an essential step for the dtic understanding the pricing, market transactions, price differentials, value chain participants, new product and technology development opportunities and the commercialisation thereof. Research suggests that the waste economy's contribution to local GDP is 0.62% at present and that this could rise to 1.5% in 10 years if the growth of the industry is supported, and that 127 000 jobs could be created.

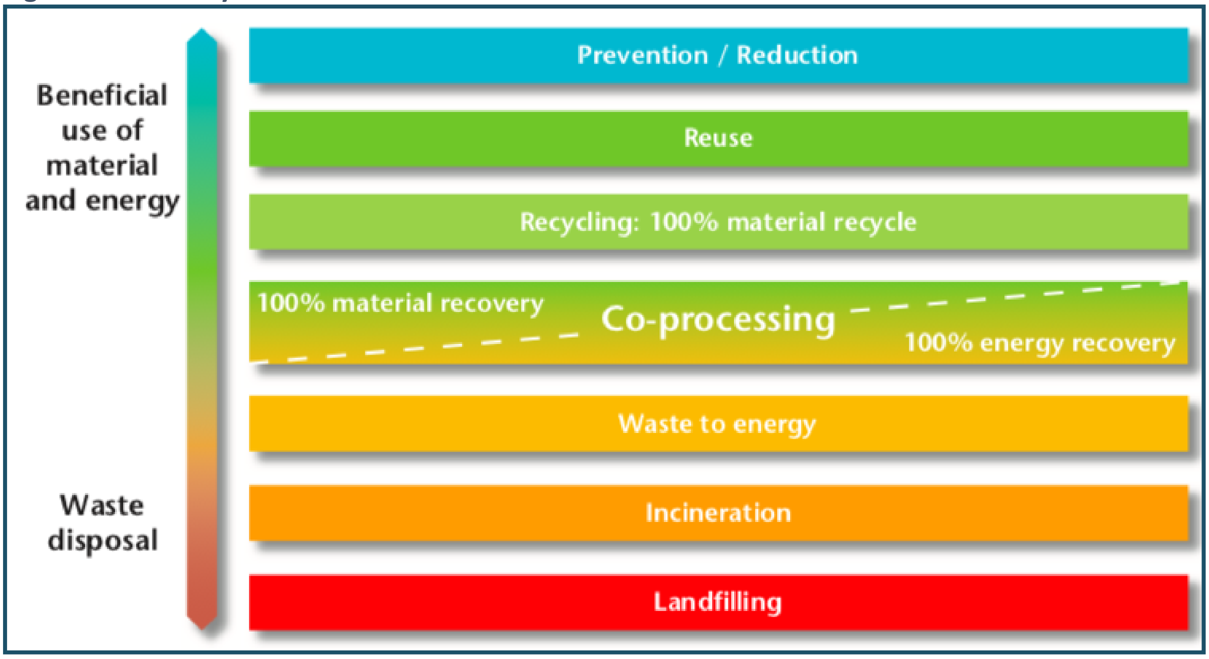
Establishing a co-processing facility at a cement plant as a means to catalyse a broader waste beneficiation industry in South Africa

Introduction

South Africa produced 108 tons of waste in 2017 and 75% of this was landfill. The remaining 25%, which was recycled, reused, reprocessed or co-processed, supported 35 000 formal sector jobs, 60 000 to 90 000 livelihoods for informal waste pickers and a private sector waste economy that has been growing on average at 10% per annum over the past seven years (Waste and Chemical Phakisa, 2019). Discussions and projects to ramp up the move away from landfill in South Africa stall because of the cost differential between landfill cost and the cost of processing waste into a useful format. The Council for Scientific and Industrial Research (CSIR) and DEFF suggest this will change as landfill costs increase in the future either as a result of government policy or due to increased municipal sanitary engineering standards which will increase both the Capex and Opex costs of landfill sites and lead to increased gate prices.[1]

Developed countries have shown that as landfill costs and policy and regulations decrease, the volume of waste which can legally or economically be discarded to landfill increases so the private sector adapts and develops technologies and uses for waste which valorise waste streams. As such, in time the view of waste changes from something which is discarded and is an expense to the producer to something which has value and can be additionally valorised through sale or various beneficiation options and uses.

Figure 1: Hierarchy of waste



Source: IFC, 2017

[1] Most municipal landfill sites in South Africa are in fact technically dump sites where waste is simply disposed of in a designated area. Dumps are not regulated by government and in most countries are illegal. A proper landfill site is regulated by government and is well-researched and specifically engineered to minimise environmental impact and to improve sanitary conditions. So, for example, landfills are situated only at sites with specific geographic and hydro-physical properties, they are lined with a membrane which prevents leeching, they are serviced and managed. Daily operations include controlling what can be disposed of, dealing with rodents, and covering and compacting waste. Most municipalities in South Africa do not have the budget to design and operate a landfill and instead essentially provide dumps.

Viewing waste as a resource is nascent in South Africa. This is essentially driven by low landfill prices (between R100 and R200 a ton in South Africa versus R1 500 to R2 000 a ton in Europe), but more importantly by a lack of knowledge and development of upstream and downstream waste value chain activity. Waste value chain activity is hard to catalyse because of the inherent complexities of waste. The waste market is highly heterogeneous (for example hazardous waste, non-hazardous waste, industrial waste, municipal waste, wet waste, dry waste). Waste is also collected through multiple channels (large formal sector waste management companies, informal pickers, municipal services, sewage works, direct relations between industrial producers and recyclers). Waste transactions occur at multiple points with varying levels of price transparency and competition (for example large waste management companies buy waste from some industrial waste generators but are paid by other waste generators to remove their waste for them; equally there are sales between waste pickers, collection companies, recyclers and downstream processors.) Finally waste in South Africa is highly politicised, especially access to municipal waste, waste ownership and the livelihoods of informal pickers. Local experts interviewed all agree that South African waste value chains and their operations are not well documented, quantified or understood and this undermines any efforts to create commercial enterprises based on waste as a valuable resource.

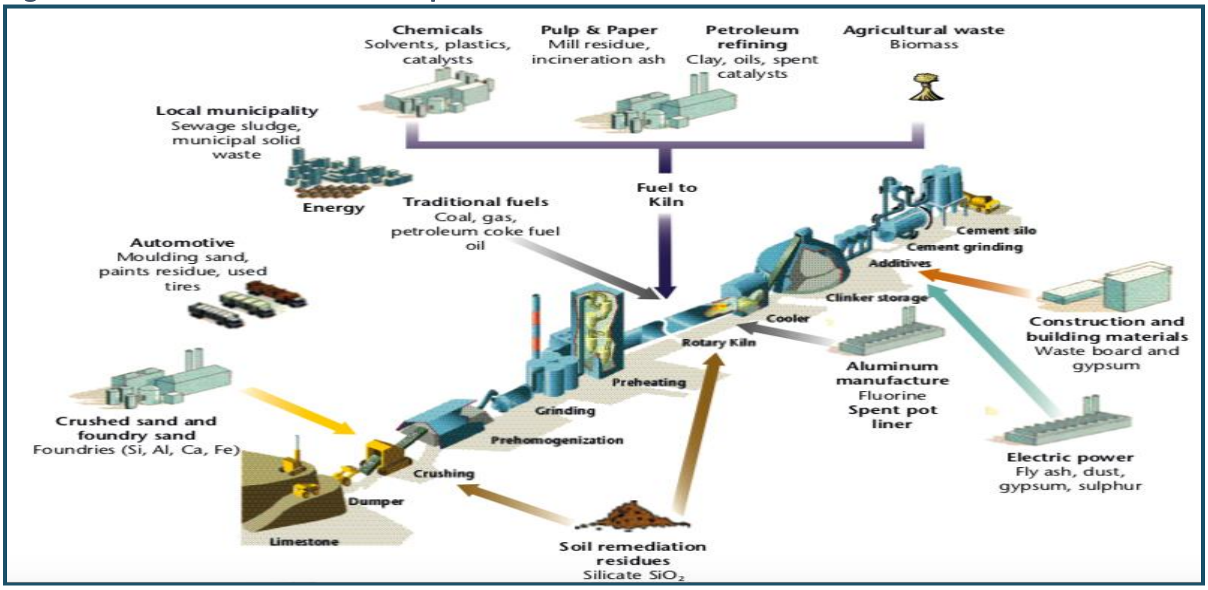
To create a future vibrant waste economy which increases the sector's contribution to GDP and job creation it is necessary for the dtic to become involved in a sector which has traditionally been the purview of environmentalists and waste management experts in DEFF and technology and innovation scientists at the DSI and the CSIR. While the former can provide an enabling regulatory and statutory environment for growth and the, latter, the know-how and technology to support new businesses, processes and products – the dtic alone can bring opportunity and knowledge together in a commercially feasible manner and catalyse a range of new economic beneficiation opportunities for the national economy. Global experience suggests that the knowledge necessary to support the growth of the waste economy comes partly from research and lessons learned from other countries, but more importantly from supporting initiatives in the commercial space and learning from their experience. This project feedback and learning paradigm is the most effective manner by which to support a new collection of economic activities, markets, value chains, prices and enterprises.

This proposal suggests one such project – establishing a co-processing facility at a cement plant to replace coal with an alternate fuel made from general industrial waste. The alternate fuel will provide the cement plant with thermal energy as well as some substitute chemicals to replace virgin raw materials. This opportunity was identified in research undertaken by TIPS in 2020 for the Green Industries Desk which looked at how cement plants can become more climate compatible and reduce their carbon footprint. Through conversations with waste experts the project is slightly repositioned as not only an intervention for the cement industry but as a broader strategic intervention to improve the dtic's understanding and development of general industrial waste value chains so as to support the future growth of the waste sector as a contributor to GDP and job creation.

The cement industry

To make cement, limestone and other minerals are quarried and crushed. Other minerals are added to this crushed stone and ground into a raw meal. This raw meal is pre-heated and then fed into a large rotary kiln where the raw meal is heated to 2 000 degrees centigrade through the burning of coal or coke. As the crushed meal moves through the kiln, some chemical elements are driven off in the form of gasses and the remaining elements combine in a process called calcination to form clinker. Clinker emerges from the kiln in the form of grey marbles where it is rapidly cooled, gypsum is added and it is finely ground into a powder known as cement. Cement is mixed with sand, water and stone to form concrete, which is the second most consumed product in the world after water and the most consumed man-made product in the world. Unfortunately during the calcining process the cement manufacturing process gives off very high levels of process CO_2 which are greenhouse gasses and contribute to global warming. In 2016 South Africa's six cement companies produced around 18 million tons of cement. Every ton of cement creates 0.87 tons of CO_2 and local industry alone contributed more than 1% of the total country's GHGs. Through the implementation of the Carbon Tax in 2020 and a commitment made by the industry to reduce its carbon footprint, local firms have been looking at ways to decarbonise the industry. The TIPS Report considered all the possible options available to the industry using best available technology and global best practice to decrease its carbon footprint. One such option is for cement kilns to burn alternate fuels instead of fossil fuels. International literature shows that alternative fuel usage can decrease carbon emissions from the industry by 40% of the total decrease required in the two degree climate change scenario (WWF, 2017; Leanne and Preston 2018; Zero Carbon Australia, 2017). The substitution rate of alternative fuels for fossil fuels in cement plants differs across the world depending on environmental policies and the availability and cost of waste. Substitution rates in Germany are 65%, 60% in Belgium, 45% in Sweden and Poland, 30% in France, 20% in the UK, 15% in Japan and just 8% in Brazil (IFC, 2017). Eighty-eight percent of South African cement plant energy is provided by burning coal (Vosloo and Mathews, 2017). Currently alternate fuel is not used in the local cement industry except in two plants where very small quantities of tyres were burned when DEFF paid the plant to dispose of them.[2]

Figure 2: Use of waste at a cement plant



Source: WWF (2017)

Alternate fuels in the cement industry

Chemically and technically almost all types of waste can be used to generate some thermal energy which is measured by the waste's calorific value when burned. So, for example, a ton of coal generates 29 gigajoules (gj) of energy while used tyres generate 36 GJ/t and biomass on average just 17 gJ/t. Moisture content impacts calorific value and most waste streams are dried to minimise moisture content before being processed or burned. The most typically classified waste streams are: hazardous waste; general industrial waste; municipal solid waste; municipal sewage sludge; biomass; and unclassified other wastes (which is usually a category dominated by used tyres). Non-hazardous general industrial waste and tyres are the most valuable and viable waste streams for cement firms

[2] DEFF has subsequently changed its policy and no longer pays firms to dispose of used tyres.

to consider as sources of alternative fuels. The main local industries producing non-hazardous industrial waste are: wood and furniture; paper and cardboard; metallic equipment; automotive; food; rubber and plastics; electrical and electronic equipment; and the footwear and textile sectors (IFC 2017).

Table 1: Non Hazardous Industrial general waste in South Africa 2011

WASTE STREAM	VOLUME (Million Tons per annum	RECYCLING RATE (%)	AVERAGE CALCULATED VALUE[1] (Rand per Ton)
Paper	1.7	57	744
Plastic	1.3	18	3119
Glass	0.9	32	490
Metals	3.1	80	2270
Tyres	0.64	4	367
Oil	0.12	44	2777

Source: DST (2014) [1] For methodology of calculated prices see DST, 2014. Average prices quoted in the table hide large price diversity within a given waste stream, for example plastics waste prices vary from R1 900 to R4 000 depending on the type of plastic.

The attraction of general industrial waste and tyres is that they are available in large and usually predictable quantities, security of supply is high, ownership is clear and the quality of the waste is good and relatively reliable. This is crucial because cement plants have very specific requirements concerning the chemical composition and calorific value of any alternative fuel they introduce into their manufacturing process. Calorific value of the fuel will determine whether it will be used to fuel the main flame burner in the rotary kiln, the pre-calciner or just the pre-combustion chamber. This will impact the amount of coal burned at the plant and its carbon footprint.

Besides calorific value, the chemical composition of the waste is crucially important as resource recovery of raw materials occurs when wastes are burned. As explained, a homogenised raw meal of inputs is heated in the manufacturing of cement and the composition of this raw meal is carefully controlled as it determines the chemical composition of the final cement product produced and hence its performance characteristics and quality. This is crucial as poor quality cement can cause concrete to fail and buildings to collapse. When waste is burnt in a kiln, chemical compounds from the waste are released and bind with the compounds in the raw meal thus becoming part of the final chemical composition of the cement. As such, if an alternate fuel is going to be utilised in the kiln the initial raw meal mix must be changed to accommodate and allow for the chemicals which will be released during the burning of waste. Similarly the chemical composition of the waste has to be consistent so that the final cement product meets chemical composition specifications and quality standards. The chemicals most often sought and recovered are: alumina, silica, calcium and iron.

Using waste as an alternative fuel and simultaneously as a source of recovered raw materials is known as co-processing. Co-processing valorises waste in two ways: as a substitute for coal as a source of energy; and as a substitute for certain chemical virgin raw materials. The aim of co-processing is to produce a specifically engineered alternative fuel with a uniform source of chemical materials and a constant thermal output which meets the specifications of the cement plant. Co-processing requires sorting, primary and secondary shredding, grinding and ultimately blending. Laboratory services to deal with chemical composition and testing are required at the sorting and blending stage.

Activities and facilities required to establish a cement co-processing plant

A co-processing plant must have a specific site set aside for receiving and sorting waste. Global best practice suggests that all waste for co-processing should be traceable. The site and facility must have a waste treatment permit and should have environmental and quality management systems which comply with local regulations and ensure the health and safety of workers. Once sorting is completed, waste materials need to be screened and analysed at a dedicated testing station which will determine levels of moisture, calorific value, chlorine, alkali and sulphur content, metals (and especially non-volatile heavy metals) and ash content. This analysis can be completed on-site or in a suitably qualified and accredited laboratory offsite.

Once the chemical and thermal parameters of the waste have been established, waste is sent to a shredding line. The degree of shredding and the final size of the shredded waste will be determined by where in the manufacturing process the alternative fuel will be burned. If the fuel is to be used in the pre-calciner, pieces of 50mm to 80mm are required, which can usually be achieved with only a single shredding. Waste passes along a conveyer belt and is shredded by passing through large rotating blades. A separator then differentiates between large and small pieces and pieces which have not been reduced to the required sized are re-circulated for a second pass through the blades. Once shredded, the waste moves through a magnetic separator. If the fuel is to be burned in the main kiln, the waste needs to be more finely ground to pieces between 20mm and 35mm big. This requires a second shredding process.

Once the fuel is of a uniform and appropriate size it may pass through a drying phase (if necessary) and then move along the facility to the inline mixing station. Mixing is crucially important to ensure uniformity of calorific value and chemical composition that conforms to the specifications of the end user. Once a homogenised product has been created, it needs to be stored until required at the cement plant. Usually a shed or silo is sufficient for storage. When required the co-processing firm will need to load the homogenised waste into suitable trucks for delivery to the cement plant. The cement plant will need to be engineered to accept and introduce the fuel into their manufacturing process. A docking station will need to be erected to take delivery of the processed waste. From the truck the waste will need to be transported to the burning location via a mechanical conveyor. At the end of the conveyor a pneumatic feeding system will need to be installed to allow feeding through a rotary valve and closing system.

To set up a co-processing plant will require i) acquisition of or access to a suitable site at or near a cement plant; and ii) civil works and utilities installation for physical infrastructure such as buildings to house the receiving station, sorting station, shredder, laboratory (if in-house), drying shed (if necessary), storage facility and docking station for delivery of processed waste. The physical infrastructure portion of a co-processing plant is a small portion of the overall project and requires basic construction materials and building techniques. For some portions, a simple metal shed will suffice. Capital equipment is the largest component in the setup cost of a co-processing facility. Depending on the use of the waste and where in the cement process it is added, one or two shredders will be required. Drying equipment may be necessary depending on the composition and source of the waste. Conveyor belts, separators and mixing equipment and balers or shapers will be required, and a fleet of trucks to move the waste from storage to the cement plant will need to be acquired. All of this capital equipment exists in the current market and overseas sourced capital equipment may need to be retrofitted or adjusted to take into account local differences and requirements. Delivery systems into a specific kiln at a specific cement plant will need to be locally produced according to site specific specifications and requirements but such engineering capacity exists in the domestic market.

If waste analysis is to be done in-house at the co-processing facility, a laboratory will need to be built and equipped. Necessary equipment for such analysis exists in the overseas market and would need to be imported.

Physical infrastructure construction and capital costs obviously depend on the size and scale of the plant and the tonnage of waste to be processed per hour. The International Finance Corporation (IFC) categorises plants with a throughput of less than five tons an hour as small facilities and plants processing more than five tons an hour as large facilities. It estimated in 2017 in Europe the capital and physical infrastructure costs for a small plant would be approximately €2 million and a large facility up to €5 million. Based on European costs of labour, electricity, waste and given health and safety requirements it estimates operational expenditure at a small plant to be approximately €40 per ton compared to €75 Euros per ton for a large facility. South African stakeholders interested in such a facility broadly anticipate an establishment cost of R30 million to R38 million for a small facility located on the premises of a cement plant. This is roughly in line with international estimates.

Key success criteria

The Cement Sustainability Initiative (CSI), which is part of the World Economic Forum's World Business Council on Sustainable Development and the IFC are both committed to providing inputs which assist the cement industry globally to decrease its carbon footprint. Co-processing is seen as one important contributor to greening the industry and to this end both organisations have researched key success factors of co-processing facilities around the world.

Not all cement firms are equal in terms of their process and their capital equipment. As such their ability to substitute co-processed waste for fossil fuels will differ. A precondition for a co-processing project is an analysis and understanding of a cement plant's kiln and its operating parameters.

A second requirement is good knowledge of various local waste streams, their availability, through what channels they can be accessed, and at what price. All research suggests that selection of waste should not be made by the cement company as they are not experts in the field. Rather it is suggested that the cement company should partner with a player from the waste industry, rather than the cement company attempting to develop its own supply chain.

Third, and crucially, control of the waste treatment process is critical to the quality and regularity of the product produced as an output of the co-processing facility. The operator of the facility must manage its operations and outputs with a strong knowledge of the operations and constraints of cement kilns. To strengthen the quality of the output the cement company must develop knowledge and procedures to check the input received from the co-processor. The CSI note that the quality of the dialogue between the operator of the co-processing facility and the cement company as the final user of the processed waste is one of the most important keys to the success of such a facility.

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