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SUSTAINABLE PRODUCTION PRACTICES

Business Cases

2019

Part of SWITCH AFRICA GREEN project

'Promoting Inclusive Sustainable Practices in the South African Clay Brick Sector'

executed by the CBA, EcoMetrix Africa and Partners for Innovation

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The SWITCH Africa Green project" Promoting Inclusive Sustainable Practices in the South African Clay Brick Sector" was initiated in 2018 and aims to promote sustainable practices in the South African clay brick sector. The project is co-funded by the European Union and executed jointly by The Clay Brick Association of Southern Africa (CBA), EcoMetrix Africa (EMA) and Partners for Innovation (PfI).

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INTRODUCTION

In an effort to continually improve the sustainability performance of the clay brick sector in South Africa, business cases have been developed to assist clay brick makers to evaluate the feasibility of implementing various sustainability measures or actions in their existing operation/s. Typically, these would be measures which can result in more cost and resource efficient clay brick production processes, leading to a reduced environmental impact whilst improving operational performance.

Three excel-based business case models have been developed to evaluate the feasibility of investments made into three specific sustainable production measures. The measures investigated include:

1. Switching to a more efficient firing technology (e.g. from a clamp kiln to a zig-zag kiln)
2. Producing perforated brick products
3. Waste symbiosis - using/adding waste products as raw materials in the clay brick production process

For all three measures, the feasibility of the investment is evaluated in terms of the potential monetary (ZAR) savings in operational costs over a 5-year period, as a result of the capital investment made into the sustainability measure. These savings are then compared to the capital investment made and are evaluated in terms of four financial measures:

- **Net present value (NPV)** – the difference of the initial investment and the value of the cash inflows over time considering a rate of return and the time value of money. A positive value is a sign the investment made will return financial benefits to the organisation
- **Profitability Index** - the ratio of the present value of cash inflows to the initial investment. A ratio of greater than 1 is a sign that the investment will return financial benefits to the organization
- **Pay-back period** - the length of time required to recover the initial cash outlay (investment) to implement the sustainability measure. It represents the amount of time required to earn back the cost incurred to make the investment through the successive cash inflows

The design of the business case models for all three of the sustainability measures evaluated is the same, with the differences being the assumptions made in each case. The design of the models, the factors considered as well as the assumptions made are discussed in the next section.

It should be noted that costs related to interest, taxation, depreciation and amortisation have not been included in the model and thus results related to operating profit are reported as earnings before interest, taxation, depreciation and amortisation (EBITDA). These costs will be factored into the business cases at a later stage once the project financing structure is discussed with the prospective brick producer who intends to implement the respective sustainability measure. The business cases have thus been developed with the intention of providing brick makers with an initial indication of project viability.

MODEL DESIGN, FUNCTIONALITY AND ASSUMPTIONS

As previously mentioned, the business case models developed are completely excel-based and all have the same design. Each model has 5 sheets:

1. **A 'Read Me' sheet** – which describes the rationale for the business case, the model components, how the business case results are reported as well as a glossary with definitions
2. **A 'Headline Inputs' sheet** – which shows the basic inputs that are required to determine the results of the business case on the sole basis of the investment cost required and specific operational variables (i.e. headline inputs). For all three business cases, these headline inputs have been pre-populated (in order to derive the business case results) but can be edited by the model user accordingly to reflect the actual performance of their current operation and the desired performance of the new operation after the investment has been made. The editable values are shown in grey cells in the sheet. The headline inputs are automatically linked to all the other sheets in the model and once entered, the overall business case results are calculated
3. **An 'Operating Variables' sheet** – an extensive sheet which shows the headline inputs entered as well as more elaborate operational variables/considerations such as clay, fuel, electricity and water consumption as well as labour. The different variables in this sheet are either automatically calculated based on the data entered in the headline inputs table or have been pre-populated and are editable by the model user. The editable values are shown in grey cells in the sheet. The data in this sheet automatically filters through to the cashflow sheet
4. **A 'Cash Flow' sheet** – which shows the annual operating income, annual operating expenses as well the annual operating profit of the current operation and that of the new operation post the investment. All of these are automatically calculated on the basis of the data in the headline inputs sheets and the operating variables sheet and therefore no values in this sheet are editable by the model user. The sheet also shows a comparison of the current operation and the new/prospective operation in terms of operational performance, looking at monetary gains and losses in specific operational costs as well as revenue. This

comparison is automatically linked to the operational performance comparison graph shown in the headline inputs sheet

5. **A 'Business Case Evaluation' sheet** – this sheet analyses the monetary savings achieved in specific operational aspects (e.g. fuel, clay or water consumption) or additional revue gained due to the investment in the sustainability measure. These savings are extrapolated over a 5-year period and evaluated against the initial investment made to determine the NPV, profitability index and the payback period of the investment

In terms of the assumptions made regarding the pre-populated data in the models, the assumptions are based largely on existing literature (e.g. the Clay Brick Life-Cycle Assessment (2016), the Energy Efficient Clay Brick (EECB) Project and clay brick project-specific business cases which were found from international studies.

Table 1 on the next page shows the assumed headline inputs, which have been pre-populated in each of the three excel business models. The pre-populated data used in the more elaborate operating variables sheets can be viewed in the respective excel files of the different business cases, which also has a comments section explaining the rationale behind certain assumptions made for specific operating variables.

		Business Case 1		Business Case 2		Business Case 3	
Variables	UoM	Clamp	Zig-Zag	Zig-Zag (solid bricks)	Zig-Zag (perforated bricks)	Clamp (No waste symbiosis)	Clamp (with waste symbiosis)
Investment Cost	ZAR	-	2,300,000	-	200,000	-	700,000
Discount Rate	%	-	10%	-	10%	-	10%
Daily Production (Green bricks)	No.	45,000	45,000	45,000	45,948	45,000	45,000
Brick Weight (extruded)	Kg	-	-	3.5	3.5	3.5	3.5
Level of brick perforation	%	0%	0%	0%	16%	0%	0%
Addition of waste stream	%	0%	0%	0%	0%	0%	5%
Price of waste product	ZAR/tonne	-	-	-	-	100	100
Monthly Operating days	days	22	22	22	22	22	22
Monthly green brick production	No.	990,000	990,000	990,000	1,010,856	990,000	990,000
Operating months per year	months	11	11	11	11	11	11
Annual green brick production	No	10,890,000	10,890,000	10,890,000	11,119,416	10,890,000	10,890,000
Waste (Drying)	%	7%	2%	2%	2%	7%	7%
Net Setting into Kiln	No.	10,127,700	10,672,200	10,672,200	10,897,028	10,127,700	10,127,700
Waste (firing)	%	5%	3%	3%	5%	5%	5%
Annual Saleable bricks	No.	9,621,315	10,352,034	10,352,034	10,352,176	9,621,315	9,621,315
Average brick selling price	ZAR/brick	2.0	2.0	2.0	2.0	2.0	2.0

Table 1 – Assumed Headline Inputs for the Three Business Cases

1 BUSINESS CASE 1 - SWITCHING FROM A CLAMP KILN TO A ZIG-ZAG KILN

1.1 Rationale

Clamp kilns have traditionally been the most dominant firing technology used in the South African clay brick sector. There are currently an estimated 84 operational clay brick production sites in the country, with close to 70% of these being clamp kiln operators. These kilns are constructed (packed) by hand and also need to be deconstructed by hand once the firing process is complete. Clay brick operations using this firing technology are thus highly labour intensive. Although over the years many brick producers in the formal sector of the country have experimented with various ways to improve the firing process of their clamp kilns, these kilns are still the most energy-inefficient and air-polluting kilns compared to other kiln types.

In an effort to curb the environmental impact of their operations and improve operational performance through better firing processes leading to lower fuel consumption and higher and better-quality production output, many clamp kiln operators in the formal clay brick making sector of the country are exploring alternative kiln types. These include the tunnel kiln, vertical shaft brick kiln (VSBK) or the zig-zag kiln.

While the VSBK is widely regarded as a very energy-efficient kiln, its penetration in the country has been low (2%), largely due to the high capital investment required for the kiln. While the kiln is highly mechanised and is therefore not labour intensive compared to the clamp kiln, it does require a relatively skilled and trained labour force for operation and maintenance. Furthermore, the VSBK is only suitable for small to medium scale brick production, unlike the other kiln types.

Although also highly mechanised and requiring a large capital investment, the tunnel kiln is the second most widely used kiln type in the country after the clamp kiln, with a market penetration of about 20%. The tunnel kiln is suitable for large scale brick production and in addition to a controlled firing process, leading to much lower energy consumption compared to the clamp kiln, offers a drying capacity that the VSBK and clamp kiln currently do not. This means that waste in the form of broken or cracked bricks, which usually occurs during open-air drying due to fluctuating day temperatures, is eliminated. Notwithstanding these benefits, the tunnel kiln is still not regarded by many brick producers as a cost-effective alternative to the clamp kiln, not only due to a high capital cost but also due to the associated high operational costs and the need for predominantly skilled labour force.

Instead of the VSBK or tunnel kiln, many clamp kiln operators in the formal clay brick sector of the country have opted to explore the potential of switching to the zig-zag kiln. Like the tunnel kiln, the zig-zag kiln offers a drying capacity as well as a controlled continuous firing process resulting in higher fuel efficiency, less GHG emissions, higher quality final products and less fired waste. All of these benefits achievable at a much lower capital cost and lower operational cost compared to the VSBK or tunnel kiln.

1.2 Technology Characteristics

1.2.1 Clamp Kiln

In clamp kilns, dry green (unfired) bricks are hand packed into a pyramid-shaped formation. Coal is placed between the bottom three layers, which is built with under-burnt or over-burnt bricks from a previous clamp kiln. Once the clamp is completely built with dry green bricks, a cover of previously under-burnt or overburnt bricks protects the new unburnt bricks from the elements. Upon completion of the construction of the kiln, the bottom layer of the kiln, which is packed with coal is ignited and progressively ignites the other two layers. The heat from these coal layers then sets the green bricks on fire one layer at a time until the whole kiln is ablaze. The body (internal) fuel within each green brick is what facilitates the progressive firing of each green brick layer. The kiln burns for up to two weeks, reaching a maximum temperature of approximately 1300°C in some cases, but typically around 1,000 – 1,100°C.

The advantage of the clamp kiln stems from its high ease of implementation and minimal cost of construction and operation, moreover, the fact that the kiln is not a permanent structure affords operators the ease of locating it close to a clay source, in order to minimize the cost of transportation and production logistics.

1.2.2 Zig-Zag Kiln

The zig-zag kiln is a continuous moving fire kiln in which the fire moves in a closed rectangular circuit through the green bricks, which are stacked in the annular space between the outer and the inner wall of the kiln. The bricks are stacked in such a manner that they form distinct chambers (~2.5 m long) and guide the air flow in a zig-zag path. The draught required for the flow of air in the kiln is created either naturally through a chimney (natural draught) or artificially by a fan (induced draught). The Zig-zag flow increases the air flow path length and turbulence in the air, thereby resulting in improved combustion & heat transfer rate and uniform temperature across the kiln cross section.

There are 3 distinct zones in the zig-zag kiln:

- **A firing zone** where the firing takes place. In a straight-line firing process, bricks are fired one line at a time at a temperature of around 900°C - 1000°C. The temperature is maintained by continuous feeding of coal at regular intervals
- **A pre-heating zone** which is stacked with green bricks and utilizes the hot air (flue gases) coming from the firing zone for drying the green bricks
- **Brick cooling zone** (behind the firing zone) where fired bricks are cooled by the cold air flowing into the kiln

The fire travels a distance of 2 chambers (~5 m) in 24 hours and fires 15,000 to 40,000 bricks. Daily, fired bricks are unloaded from the front of the brick cooling zone and an equivalent batch of green bricks is loaded ahead of the brick preheating zone.

Like the clamp kiln, the advantage of the zig-zag kiln stems from its relatively high ease of implementation and minimal cost of construction and operation. Moreover, the simultaneous drying, firing and cooling down of bricks within the kiln minimises production logistics, increases energy efficiency and decreases the quantity of drying and firing waste, resulting in a higher quantity and better quality of saleable product/s.

1.3 Business Case Results

The current business case evaluates a clamp kiln operation with a monthly green brick production capacity of circa 1 million bricks, against a prospective induced-draught zig-zag kiln operation with a similar green brick production capacity. The headline inputs assumed for both operations are indicated in Table 1 and the more elaborate operating variables are indicated in the relevant corresponding excel business model. As indicated in Table 1, the investment required for a clamp kiln operator to switch to a zig-zag kiln has been estimated to be 2,300,000 ZAR. This capital cost has been assumed to reflect costs associated with a professionally designed and engineered 9-chamber kiln (each chamber has capacity of 5,000 bricks) with a shed, a 15 - 20 HP electrically powered motor fan as well as the conducting of an environmental impact assessment, which may cost up to R300,000.

For both operations, coal (duff) and coal (nuts) have been assumed to be the body fuel and firing fuel respectively. The clamp kiln has been assumed to have a specific energy consumption of 3 Mj/kg of fired brick (can be as high as 4 Mj/kg of fired brick for less efficient kilns) and the zig-zag kiln has been assumed to have a specific energy consumption of 2 Mj/kg of fired brick (can be as low as 1.5 Mj/kg of fired brick for more efficient kilns).

1.3.1 Analysis of Operational Performance

On the basis of the aforementioned capital cost as well as the assumed headline inputs and operating variables inputs, the operational performance, in terms of monetary (ZAR) savings/losses of the prospective zig-zag kiln in comparison to the existing clamp kiln operation is shown below in Figure 1. The savings/losses are represented in percentages, with the clamp kiln's performance in each operational indicator taken as the 0% point.

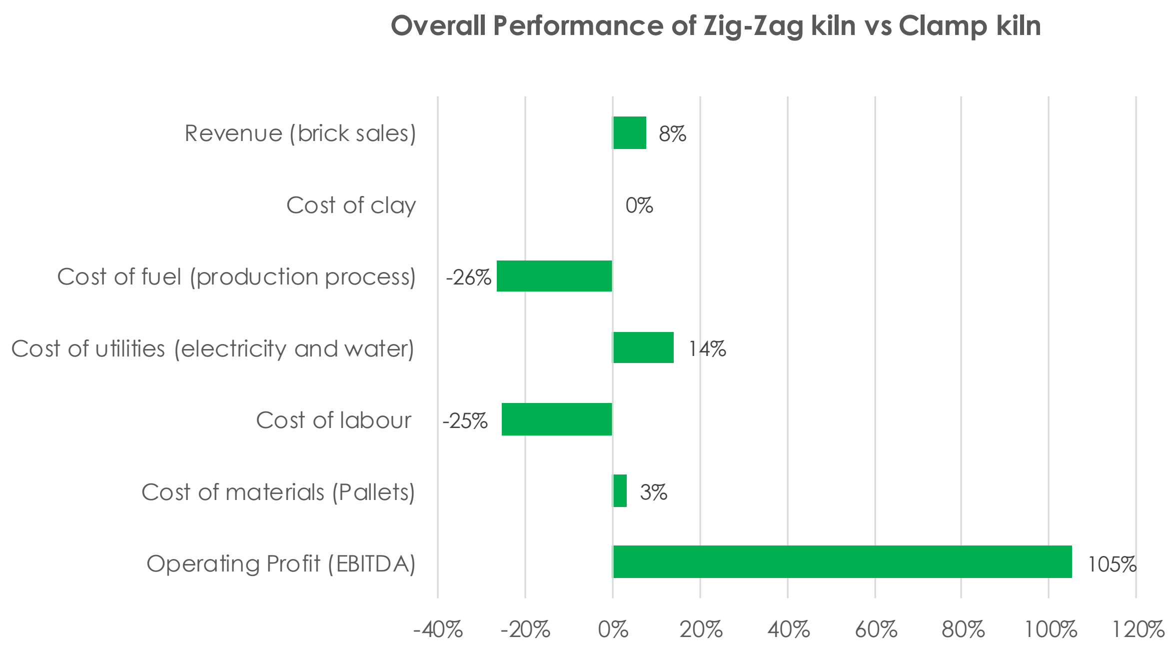

Figure 1 – Comparison of operational performance of prospective zig-zag kiln against current clamp operation (represented by 0%) - % increase/decrease in ZAR

Given that the drying of green bricks occurs within the drying zone of the zig-zag kiln and that the kiln has a more controlled firing process, much lower drying and fired waste is expected, which would yield more saleable bricks than the clamp kiln. This would translate into an increase in sales revenue. In the current business case, both operations have been assumed to produce only solid bricks, and therefore no saving can be anticipated in terms of clay consumption. Given the large difference in the specific energy consumption between the two kilns, fuel costs savings collectively (body and firing fuel) are expected to be as large as 26% for the zig-zag kiln compared to the clamp kiln. The cost for utilities, specifically electricity is expected to increase when switching to a zig-zag kiln due to the electrically powered fan. The cost of labour is expected to decrease substantially when switching to a zig-zag kiln because fewer workers are required for tasks such as brick packing and sorting unlike on clamp kiln operation which is very labour intensive in this regard. Given that the zig-zag operation would have a higher saleable brick production, more materials (i.e. pallets) would be required for brick loading and delivery. Overall, when comparing the operating income and the operating expenses of the prospective zig-zag kiln to the current clamp operation, an overall operating profit increase of more than 100% is expected.

In addition to the operational savings described above, the more energy efficient zig-zag kiln will also result in substantially less greenhouse gas (GHG) emissions than the current clamp kiln.

The model results in this regard are demonstrated in the Table below.

Table 2 – Comparison of Annual Energy and GHG Emissions Performance

	UoM	Clamp	Zig-Zag	% Change
Internal fuel consumption	GJ	62,209	60,511	3%
Firing fuel consumption	GJ	33,497	6,723	80%
Total emissions per annum	tCO_2e	9,192	6,483	29%

1.3.2 Business Case Evaluation

The financial feasibility of switching to a zig-zag kiln from a clamp kiln has been evaluated by comparing the initial capital outlay (investment) against the additional operating revenue that will be gained due to savings in fuel consumptions as well as the revenue that will be gained from additional brick sales. Other savings such as labour have not been taken into account, because while in reality these will be achieved, the magnitude of these savings is highly dependent on the assumed labour (quantity) and labour costs, which is too uncertain.

On the basis of the fuel cost savings only, over a 5-year period, the payback period of the initial investment made is expected to be **less than 2 years** (1 year, 6 months). The NPV and profitability index are also shown below:

Table 3 – Business Case Results (Fuel Cost Savings Only)

Variables	UoM	Value
Net Present Value (NPV)	ZAR	3,168,067
Profitability Index	Ratio	2.4
Payback period	years	1.6

When taking the sum of the savings achieved in fuel costs and the additional revenue gained in brick sales, over a 5-year period, the payback period of the initial investment made is expected to be **less than 1 year** (approximately 8 months). The NPV and profitability index are also shown below:

Table 4 – Business Case Results (Fuel Cost Savings and Additional brick Sales Revenue)

Variables	UoM	Value
Net Present Value (NPV)	ZAR	12,219,501
Profitability Index	Ratio	6.3
Payback period	years	0.8

2 BUSINESS CASE 2 – PERFORATED BRICK PRODUCTION

2.1 Rationale

The majority (more than 70%), of the clay bricks produced in South Africa are unperforated. On the one hand, the low production of perforated bricks can be attributed to the predominant use of the clamp kiln as a firing technology in the country, which does not easily lend itself to the firing of perforated products. On the other hand, the traditional solid clay "plaster" brick is still deeply entrenched in the South African building sector and is therefore still widely manufactured and preferred over perforated products.

In the midst of rising raw material costs, energy costs and the carbon tax, the shift to perforated bricks is an untapped opportunity for many clay brick makers to benefit from reduced material and energy costs, while maintaining the same levels of production.

2.2 Technology Characteristics

Perforating a clay brick is the act of extruding the clay body such that there are voided areas or holes within the resulting brick. Depending on an operation's clay preparation process and existing extrusion process, no changes in this regard may need to be made in order to start producing perforated bricks. Changes may be limited to the retrofitting of the existing extrusion system with a bridge piece, core rods, core bridge tips and die oil lubrication plates. Notwithstanding this, the change to perforated brick production necessarily requires a step-by-step approach, preferably with the guidance and help of a local equipment supplier that can bring the necessary expertise. An imbalanced die may lead to invisible brick cracking during drying which would only become apparent after firing due to an increase in fired waste.

Figure 2 – Solid clay brick vs perforated clay brick

2.3 Business Case Results

Building on the example of the zig-zag kiln operation modelled in Business Case 1, the current business case evaluates an induced-draught zig-zag kiln operation with a monthly green brick production capacity of circa 1 million bricks, producing only solid bricks, against a prospective induced-draught zig-zag kiln operation with a similar green brick production capacity, producing only perforated bricks. The headline inputs assumed for both operations are indicated in Table 1 and the more elaborate operating variables are indicated in the relevant corresponding excel business model. As indicated in Table 1, the investment required for the current operation to start producing perforated bricks has been estimated to be 200,000 ZAR. This investment cost has been assumed to reflect costs associated with retrofitting the current extrusion system with a bridge piece, core rods, core bridge tips and die oil lubrication plates. It is assumed that this cost would also cover any associated costs related to potential changes that may need to be made to the clay preparation process.

For both operations, coal (duff) and coal (nuts) have been assumed to be the body fuel and firing fuel respectively. Both kilns have been assumed to have a specific energy consumption of 2 Mj/kg of fired brick. A 16% perforation level has been assumed for the prospective zig-zag operation producing perforated bricks. On the basis of a normal 3.5 kg unfired (wet) solid brick weight, which has been assumed for both operations, this level of perforation would result in an unfired brick weight of 2.94 kg.

2.3.1 Analysis of Operational Performance

On the basis of the aforementioned investment cost as well as the assumed headline inputs and operating variable inputs, the operational performance, in terms of monetary (ZAR) savings/losses of the prospective zig-zag operation producing perforated bricks in comparison to the existing zig-zag operation producing only solid bricks is shown below in Figure 3. The savings/losses are represented in percentages.

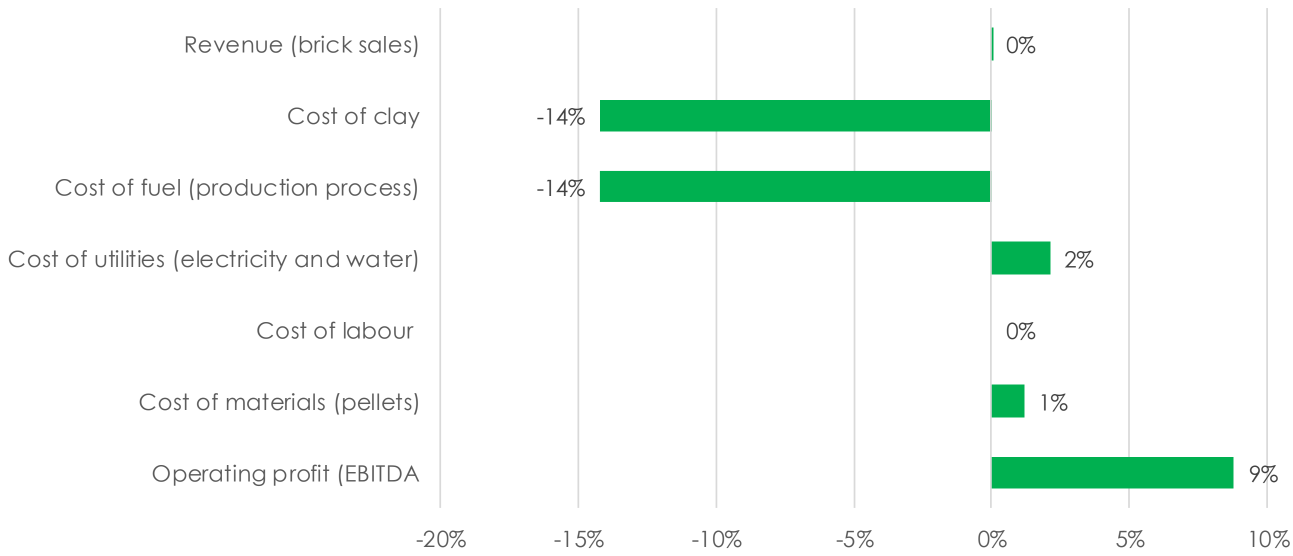

Figure 3 – Comparison of operational performance of prospective zig-zag kiln (perforated bricks) and current zig-zag kiln operation (solid bricks) (represented by 0%) - % increase/decrease in ZAR

The lower mass of the perforated bricks compared to the solid bricks produced in the existing operation results in a lower clay requirement during the clay preparation process and similarly, due to a lower brick mass that needs to be fired, a lower body and firing fuel requirement. Notwithstanding this, perforated brick production typically does result in slightly higher production of fired waste, which therefore necessitates a slightly higher production of green bricks in order to compensate for this so as to maintain the same level of saleable brick production. Compared to the existing zig-zag operation, this would necessarily result in a higher consumption of utilities (water and electricity) as well as materials. Overall, when comparing the operating income and the operating expenses of a zig-zag operation producing perforated bricks to the current zig-zag operation producing solid bricks, an overall operating profit increase of 9% is expected.

In addition to the operational savings described above, the lower fuel consumption resulting from perforated brick production will also result in substantially less GHG emissions than the current operation zig-zag operation producing solid bricks. The model results in this regard are demonstrated in the Table below.

Table 5 – Comparison of Annual Energy and GHG Emissions Performance

	UoM	Zig-Zag (Solid bricks)	Zig-Zag (perforated bricks)	% Change
Internal fuel consumption	GJ	60,511	51,900	-17%
Firing fuel consumption	GJ	6,723	5,767	-17%
Total emissions per annum	tCO_2e	6,483	5,560	-17%

2.3.2 Business Case Evaluation

The financial feasibility of switching to perforated brick production from solid brick production in the current zig-zag operation has been evaluated by comparing the initial capital outlay (investment) against the additional operating revenue that will be gained due to savings in clay consumption and fuel consumption.

On the basis of the clay and fuel cost savings, over a 5-year period, the payback period of the initial investment made is expected to be **less than 1 year** (approximately 3 months). The NPV and profitability index are also shown below:

Table 6 – Business Case Results

Variables	UoM	Value
Net Present Value (NPV)	ZAR	2,190,560
Profitability Index	Ratio	12.0
Payback period	years	0.3

3 BUSINESS CASE 3 – WASTE SYMBIOSIS

3.1 Rationale

Waste symbiosis is the practice of recycling waste products by incorporating them into the production of other products (i.e. clay bricks). This is a practical and environmentally friendly solution, curbing the costs and negative environmental externalities associated with waste disposal.

A variety of different wastes have been investigated by researchers and clay brick manufacturers for their potential as additives into the production of clay bricks. The most common waste types which have been investigated are fly ash produced in coal-fired power stations, sludge derived from municipal waste water treatment plants, waste paper and recycled glass. Other materials which have been investigated include, pulp residues, polystyrene, tobacco and grass. Regarding paper pulp, the main benefits of incorporating this into the brick production process relate mainly to a reduction in fuel consumption, clay consumption as well as in the amount of water consumed in the raw material preparation process. The latter is because paper pulp can have a moisture content of up to 90%. Other benefits include a reduction in the weight of the extruded brick, dry brick and fired brick. Collectively, these benefits will result in material savings in operational costs and will also lead to a sizeable reduction in GHG emissions.

Although waste symbiosis is a sustainability measure which can be implemented irrespective of the type of firing kiln used, this particular example focuses on a clamp kiln operation producing solid bricks with no addition of any waste material, that is considering using paper pulp as an additive to its raw material mix.

3.2 Technology Characteristics

The pulp and paper industry is characterized by four major processes: (i) chemical pulping (Kraft or sulphate pulping), (ii) mechanical and chemi-mechanical pulping, (iii) recycled fibre processing and (iv) paper-making related processes. The chemical pulping process produces several residues including inorganic sludge (dregs and lime mud), wood, straw or reed residues, sludges from effluent treatment (inorganic material, fibres and biological sludge), dust from boiler sand furnace. By-products and residues from mechanical and chemi-mechanical pulping include wood, straw and reed residues, fibre rejects, excess sludges from external biological waste water treatment.

The by-products and residues from the pulp and paper industry are managed using several approaches including land filling, incineration, use in cement plant and brickworks, agricultural use and composting, anaerobic treatment, recycling and others. Due to the high organic contents and calorific values of these residues, incineration is generally favoured.

Paper pulp (or paper sludge) has been widely used by many clay brick makers internationally in their brick production processes. Apart from the high water content (typically over 50%) of paper pulp, which can displace a significant amount of water that is used in the brick production process, paper pulp also has a calorific value that (typically around 5 - 16 Mj/kg) also makes it suitable as a body fuel. In addition to these benefits, paper pulp has been noted to improve the thermal insulation properties of clay bricks during the use phase.

For the current zig-zag operation to start incorporating paper pulp into its raw material mix, changes to the existing operation are expected to be limited only to the clay preparation process, whereby additional basic infrastructure such as a box feeder may need to be installed as well as a storage area. No changes to the existing extrusion system are expected to be required. Furthermore, a waste license may be required, which is a legal requirement for using a waste product stream in the production process and a full EIA would need to be conducted. While this sustainability measure has been successfully applied by a number of clay brick manufacturers world-wide, it is recommended that a producer considering implementing this measure, should first conduct a significant number of tests/trials in order to discern the best way of introducing this waste stream into their current production process.

3.1 Business Case Results

The current business case compares an existing clamp kiln operation, against how the same operation would perform if paper pulp was added into the brick production process. The headline inputs assumed for both operations are indicated in Table 1 and the more elaborate operating variables are indicated in the relevant corresponding excel business model. As indicated in Table 1, the investment required for the current clamp kiln operator to start incorporating paper pulp into their production process (i.e. as a body fuel and clay filler) has been estimated to be 700,000 ZAR. This investment cost has been assumed to reflect costs associated with installing a box feeder as a well as the building of a storage area for the paper pulp. It is assumed that this cost would also cover the cost of obtaining a waste license as well as the cost of conducting an EIA.

For both operations, coal (duff) and coal (nuts) have been assumed to be the body fuel and firing fuel respectively, with the exception that in the prospective clamp kiln operation, paper pulp is also used a body fuel. In the case of the later, the operation's fuel mix has been modelled to comprise 50% (coal – duff), 5% (paper pulp) and 45% (coal – nuts).

Although in some cases, brick producers are able to obtain waste streams free of charge, in the current business case, a purchase price of 100 ZAR/tonne of paper pulp has been assumed. Both kilns have been assumed to have a specific energy consumption of 3 Mj/kg of fired brick as well as a 0% brick perforation level.

3.1.1 Analysis of Operational Performance

On the basis of the aforementioned investment cost as well as the assumed headline inputs and operating variable inputs, the operational performance, in terms of monetary (ZAR) savings/losses of the prospective operation incorporating paper pulp into it's production process, in comparison to the existing operation is shown below in Figure 4. The savings/losses are represented in percentages.

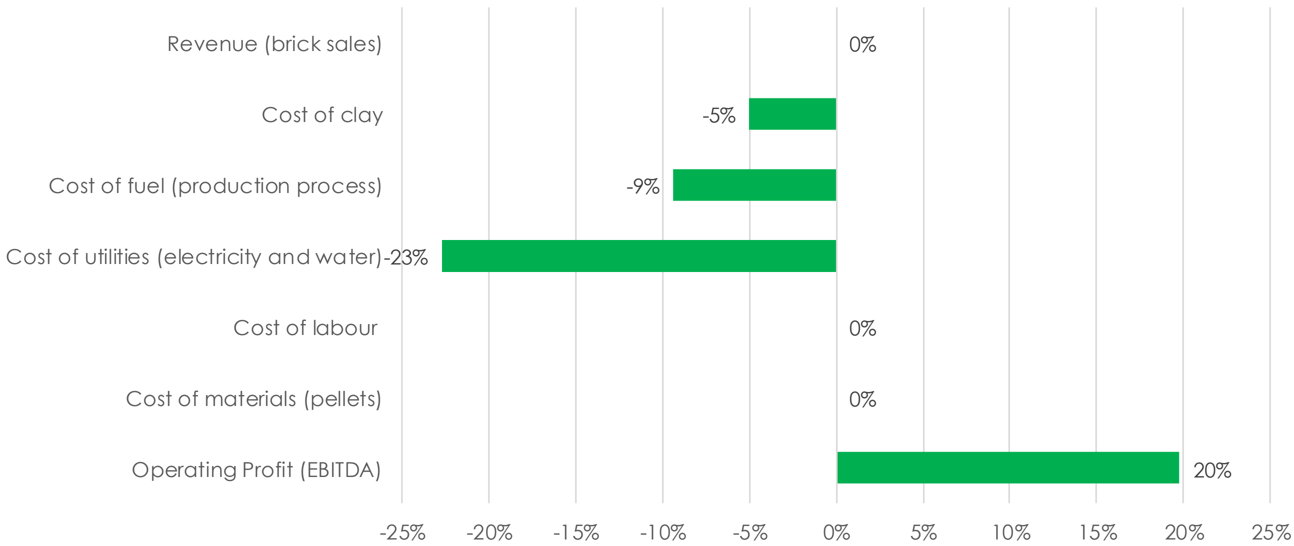

Figure 4 – Comparison of the operational performance of the prospective Clamp kiln (paper pulp) and the current clamp kiln operation (no paper pulp) (represented by 0%) - % increase/decrease in ZAR

Introducing a proportion of 5% paper pulp into the production process as a clay and body fuel replacement leads to a significant cost reduction in clay and fuel consumption, however, it should be noted that due to the lower calorific of paper pulp compared to coal (duff), much higher firing fuel quantities may need to be used to counter the lower body fuel energy content of the bricks. This is a careful balance that a brick producer would need to establish during tests/trials. Given the high-water content of paper pulp, a significant (more than 50%) amount of the water consumed in the brick production process can be saved, leading to lower expenditure in utility costs, depending on where water in the current operation is sourced from. Overall, when comparing the operating income and the operating expenses of the operation with waste symbiosis to the current clamp kiln operation, an overall operating profit increase of 20% is expected.

In addition to the operational savings described above, the lower fuel consumption resulting from a reduced consumption of coal (duff) as a body fuel, will also lead to a significant reduction in GHG emissions compared to the current operation. The model results in this regard are demonstrated in the Table below.

Table 7 – Comparison of Annual Energy and GHG Emissions Performance

	UoM	Clamp operation (without waste symbiosis)	Clamp operation (with waste symbiosis)	% Change
Internal fuel consumption	GJ	57,424	50,077	-15%
Firing fuel consumption	GJ	38,283	40,915	6%
Total emissions per annum	tCO_2e	9,185	8,719	-5%

3.1.2 Business Case Evaluation

The financial feasibility of incorporating paper pulp, as a body fuel, in the brick production process of the current clamp kiln operation has been evaluated by comparing the initial capital outlay (investment) against the additional operating revenue that will be gained due to savings in water and fuel consumption.

On the basis of the water, fuel and clay cost savings, over a 5-year period, the payback period of the initial investment made is expected to be **less than 2 years** (approximately 1 year,1 month). The NPV and profitability index are also shown below:

Table 8 – Business Case Results

Variables	UoM	Value
Net Present Value (NPV)	ZAR	1,776,694
Profitability Index	Ratio	3.5
Payback period	years	1.1

FINANCING OPTIONS

While the investment financing structure has not been considered in all three business cases, there are number of financing options available to finance the required investments. These include:

- Equity
- Debt – asset or non-asset-based finance obtained from a financial institution in the form of a loan
- Grants
- Tax incentives (e.g. 12I and 12L)
- Carbon offsets

The most suitable financing option depends on the capital requirements of the project and the suitability of the project for that particular financing option. All of these options can be explored with brick makers looking to invest in any one of the three sustainability measures covered in the business cases. It is also often possible to use more than one financing option, for instance where a portion of the investment required is financed through debt and the remainder through equity, whilst also being eligible to benefit from a tax incentive due to the environmental impact of the project. This benefit can be factored in a funding proposal to enhance the attractive of the business case for the investment.

CONCLUSION

The business case results developed for the three sustainability measures presented in this report represent an initial basis for clay brick makers to see the attractiveness and financial feasibility of improving the sustainability performance of their operations, whilst also maintaining or improving operational performance. The intension of the excel-based business models is for clay brick producers to be able to model their current operation/s against what it may look like if they were to make an investment into any of the three sustainability measures presented. The models are dynamic and interactive and are user friendly. These business cases will then serve as a preliminary base from which funding proposals can be developed, should a brick producer seek financial assistance from financiers, should they want to invest in a particular sustainability measure.

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