Vertical shaft brick kiln (VSBK) is a continuous, updraft, moving ware kiln in which the fire remains stationary while there is counter current heat exchange between air (moving upward) and bricks (moving downward).

The VSBK technology has evolved from the traditional up-draught kilns in rural China during late 1950s; however, the widespread dissemination of the technology took place after the economic reforms. At its peak during mid 1990s, thousands of VSBKs were reported to be operating in China.

Since 1990, under different technology transfer projects the technology has been transferred to several developing countries including India, Nepal, Vietnam and since 2010 in South Africa. South African brick makers and service providers have been able to innovate and have added new features to the technology, and in the process have transformed a rural technology into an industrial technology suitable for large scale production.

### About the Kiln Enterprises Using This Technology

<table>
<thead>
<tr>
<th>Kiln</th>
<th>Nature of enterprise</th>
<th>Level of mechanization</th>
<th>Brick produced</th>
<th>Production capacity</th>
<th>Operational season</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTINUOUS MOVING WARE</td>
<td>INDUSTRIAL</td>
<td>SEMI MECHANIZED</td>
<td>SOLID AND PERFORATED</td>
<td>SMALL &amp; MEDIUM Between 0.5-6.0 million bricks per month</td>
<td>PERENNIAL</td>
</tr>
</tbody>
</table>

### Number of VSBK’s in SA

<table>
<thead>
<tr>
<th>Operations</th>
<th>Shafts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>3¹</td>
</tr>
<tr>
<td>Under Development</td>
<td>2</td>
</tr>
</tbody>
</table>

¹ Includes one plant with 27 shafts utilising a different construction methodology, constructed prior to the VSBK project.

### Economic Sustainability

- Improved profit margin
- Reduced firing fuel required & Emissions Tax
- Lower fired waste & Improved yield
- Improved productivity
- Higher quality
- Greater product flexibility
- Favourable production cycle

### Environmental Sustainability

- Reduced GHG emissions
- Contributes to resource efficiency
- Reduced operational footprint

### Social Responsibility

- Improved working conditions
- Reduced exposure to particulates
- Skills development & Improved job security

### South African Benefits

- Improved working conditions
- Reduced exposure to particulates
- Skills development & Improved job security
**1: Kiln**
The vertical shaft brick kiln is a continuous, moving ware kiln in which bricks are fired in a vertical shaft of rectangular cross-section. The height of the shaft is around 6 – 8 m and nominal cross-section of the shaft 1.90 x 1.40 m. The kiln consists of banks of multiple shafts. The shafts are enveloped by an outer wall made up of bricks and the gap between the shaft and outer kiln wall is filled with insulating material.

**2: Exhaust**
The shafts have their exhaust gas ducting connected to a common exhaust.

**3: Loading**
Green bricks are loaded from the top of the shaft in batches. The fuel, in the form of coal (small nuts), is laid along with the green bricks. Common practice is that internal fuel in the form of coal fines within the clay body is supplemented by a small quantity of external fuel.

**4: Firing Zones**
Green bricks loaded from the top, gradually move down the shaft. The peak firing temperature is at the middle of the shaft, where combustion of fuel is taking place. Fired bricks after cooling are unloaded at the bottom. There are 3 distinct zones in an operating VSBK:

4.1 Brick preheating zone: It is in the upper section of the shaft where the green bricks get preheated by the hot flue gases on their way to the exhaust flue.

4.2 Brick firing zone: It is located in the middle of the shaft where fuel combustion and vitrification of the bricks is taking place.

4.3 Brick cooling zone: It is in the lower section of the shaft where the hot fired bricks are cooled down by the ambient air entering into the shaft.

**5: Counter Current Principle**
Air for combustion enters the shaft from the bottom (5.1). It gets preheated by the hot fired bricks in the lower section of shaft (brick cooling zone) before reaching the combustion zone. After combustion, the hot flue gases preheat the green bricks in the preheating zone before exiting the kiln through the exhaust flue (5.2).

The kiln works as a very efficient counter current heat exchanger where the heat transfer takes place between the air moving up (continuous flow) and the bricks moving down (intermittent movement) in the shaft.

**6: Unloading**
The brick setting in the shaft is supported on removable bars (6.1) provided at the bottom of the shaft. Brick unloading is carried out in batches from the bottom with the help of a trolley (6.2). Generally, in every 2-3 hours, one batch is unloaded at the bottom and a batch of green bricks is loaded at the top. At any given time, there are typically 12 - 14 batches in the kiln.
**VERTICAL SHAFT BRICK KILN TECHNOLOGY (VSBK)**

**MEASURED EMISSION FACTORS**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>SANS 1979-2009</th>
<th>VSBK</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO₂</td>
<td>1 Hour, µg/Nm³</td>
<td>24 Hour, µg/Nm³</td>
</tr>
<tr>
<td>NOₓ</td>
<td>1 Hour, µg/Nm³</td>
<td>1 Year, µg/Nm³</td>
</tr>
<tr>
<td>PM₁₀</td>
<td>24 Hour, µg/m³</td>
<td>1 Year, µg/m³</td>
</tr>
</tbody>
</table>

**Source:** Occupational Health Risk and Environmental Emissions Assessment Report, March 2012

**Commonly Used Fuels**

- Coal
- Fly Ash

**SPECIFIC ENERGY CONSUMPTION**

Energy consumed for firing 1kg of fired brick

Average: 0.9 MJ/kg of fired bricks

**Capitol cost of kiln technology**

For a six-shaft VSBK with annual production capacity of 11-13 million bricks and including the building, but would be site specific.

<table>
<thead>
<tr>
<th>Types of product that can be fired in the kiln</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid bricks</td>
</tr>
<tr>
<td>Perforated bricks</td>
</tr>
<tr>
<td>Roof tiles</td>
</tr>
<tr>
<td>Floor tiles</td>
</tr>
</tbody>
</table>

**Product Quality**

As per the production records

- **GOOD ~ 96%**
- **LOSSES / BREAKAGES ~ 4%**

**Capital cost breakdown**

- Construction Material: 60%
- Labour: 20%
- Equipment: 20%

**Exposure to Respirable Suspended Particulate Matter**

The VSBK has a permanent kiln structure and with the introduction of the exhaust stacks in the kiln (the initial VSBKs of China did not have chimneys), the air pollutants concentration in the working environment is low and the exposure of workers to air pollution is reduced to within prescribed South African standards.

**Usual annual Occupational Hygiene Monitoring as per the South African regulations is conducted.**

**Exposure to Thermal Stress**

Because of the enclosed working areas around the kiln, workers working on the kiln are protected from the direct exposure to sun and exposure to heat stress is very low.

This reduces the thermal stress and consequent risk of eye & skin diseases and dehydration among workers.

**Worker Safety**

Properly constructed VSBKs having mechanised brick lifting and brick unloading processes potentially expose workers to accidents. However, these risks are managed through the process of risk assessments, the application of safety measures and proper training.

- **Low risk of injuries**

**CO₂ Reduction**

Average: 400 ton CO₂ emissions reduction per annum compared to clamp kilns

**COMMENTS ON EMISSIONS**

Low fuel consumption and better combustion result in low emissions. Practice of using internal fuel further helps in reducing the emissions.

**SANS 1979-2009 VSBK**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>1 Hour, µg/Nm³</th>
<th>24 Hour, µg/Nm³</th>
<th>Predicted, µg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO₂</td>
<td>350</td>
<td>125</td>
<td>7.8</td>
</tr>
<tr>
<td>NOₓ</td>
<td>200</td>
<td>21.5</td>
<td>9.1 (total)</td>
</tr>
</tbody>
</table>

**Actual Results vs Statutory Limits ([@25 °C and 101.3 kPa])**

**Source:** Occupational Health Risk and Environmental Emissions Assessment Report, March 2012

**Fuels and Energy**

**Coal**

Because of proper combustion of fuel, efficient heat transfer and minimal heat losses, VSBK is one of the most energy efficient brick kiln firing technology.

A very efficient counter flow heat transfer arrangement between air and bricks, uniform fuel distribution and sufficient insulation around the kiln contribute to the efficiency of a VSBK.

**MAIN CAUSES FOR HEAT LOSS**

The main sources of heat loss in a VSBK are the flue gases and fired bricks coming out of the kiln.

**Factsheet: Vertical Shaft Brick Kiln, South Africa**

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**Payback Period**

Simple Payback: 2.0 - 3.0 years
Further Contact Information

FOR MORE INFORMATION:
The VSBK support network of service providers, hosted by the EECB project offer their services independently of each other, supporting the clay brick manufacturer through the various processes required when acquiring the VSBK technology.

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