

# 7 DOWNDRAFT KILN

## INTRODUCTION AND HISTORY

This type of downdraft kiln has a rectangular shape with a dome at the top and several openings at the side to inject air and fuel. The principle of operation consists in the downdraft or ascendant flame.

This model has been adopted as an improved version of the open-pit fire kiln; compared with this, the downdraft kiln is more efficient and has better distribution of the heat into the kiln; as a result, the quality of products is also improved.

In addition, the downdraft kiln complies with air emission limits for NO<sub>x</sub>, SO<sub>2</sub> and CO. The model was developed and built in conjunction with the brick producers in Cusco-Peru (San Jeronimo), and then replicated in Cuenca- Ecuador.

The combustion starts at the front, rear and lateral zones of the kiln (12 burners), at the beginning of the burning process the gases produced by the combustion move towards the roof of the dome, then the heat goes

down through the bricks and finally through the small apertures at the floor. The flue gases leave the kiln through an underground duct and move to the chimney. The draft is forced with a fan.

The fuels commonly used are logs, branches, pieces of wood and sawdust.

## GEOGRAPHICAL DISTRIBUTION:



### TYPE OF KILN

kiln



Intermittant

### CHARACTERISTICS OF ENTERPRISES USING THIS TECHNOLOGY:

Nature of Organisation



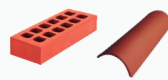
Artisanal

Level of  
mechanisation



Semi-mechanised

Type of bricks/ tiles  
produced



Solid bricks  
Hollow/perforated  
bricks

Annual production capacity  
of the enterprise



< 0.5 million bricks  
(micro scale)

Operational period



Round the year

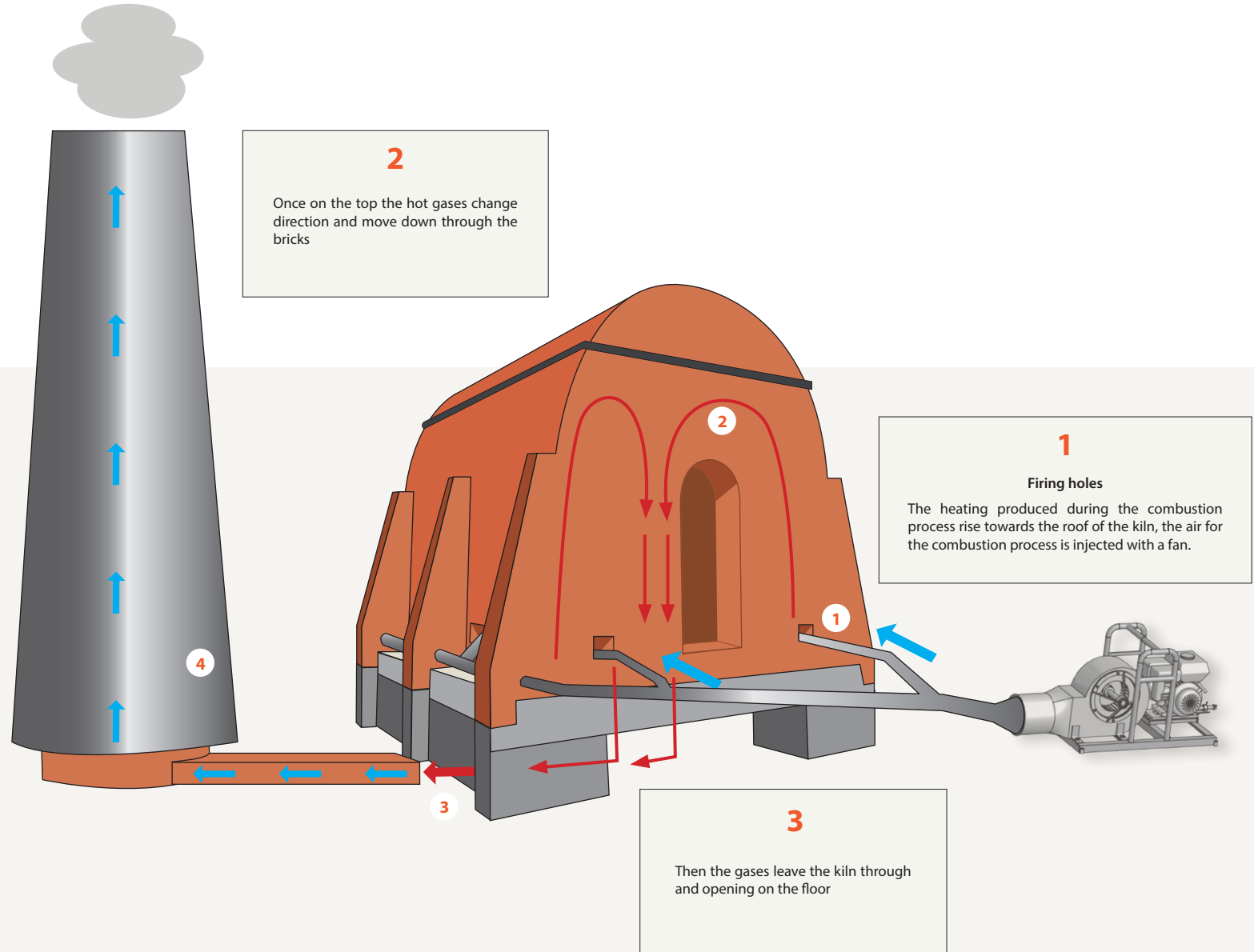
### ESTIMATED N° OF OPERATIONAL ENTERPRISES AND TOTAL PRODUCTION (USING DOWNDRAFT KILN)

Country	N° of enterprises	Total Production (million bricks or tiles year)
Perú	~ 3	~ 0.5
Ecuador	~1	~ 0.5

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## DESCRIPTION & WORKING:

The complete production cycle in the kiln is: 04 - 07 hours for loading the bricks, 12 - 16 hours for firing process (including pre heating) and up to 02 days for cooling process; these periods depend on the type of product, raw material and fuel used. The operation temperature range from 800 to 1000°C.



## 7

## DOWNDRAFT KILN

## AIR EMISSIONS AND IMPACTS:

MEASURED EMISSION  
FACTORS<sup>1</sup>

(in g/kg fired bricks)

CO <sub>2</sub>	Black Carbon (BC)	Particulate Matter (PM)	CO
100,9 g/kg brick Average	Not available	Not available	2,96 g/kg brick Average

## MEASURED PM EMISSION

Average: Not available

## EMISSION STANDARDS

Emission standards for the brick industry in Peru are in a process of discussion at the government level, include particulate matter and gases. The regulation is in process to be approved, values above reported apply for solid fuels.

Country	Perú
PM (mg/Nm <sup>3</sup> )	150
NO <sub>x</sub> (mg/Nm <sup>3</sup> )	650
SO <sub>2</sub> (mg/Nm <sup>3</sup> )	500
CO (mg/Nm <sup>3</sup> )	1000

## COMMENTS ON EMISSIONS

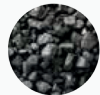
The emissions of this kiln depend on the relation air/fuel injected; good practices applied under the operation process result of low level emissions of soot and gases; indeed, due to the downdraft principle of operation; the bricks act as a filter retaining some portion of the particles produced.

## FUEL AND ENERGY:

## COMMONLY USED FUELS



**Biomass** (eg. firewood, biomass briquettes, sawdust).



**Mineral coal**

SPECIFIC ENERGY CONSUMPTION<sup>2</sup>  
(SEC)

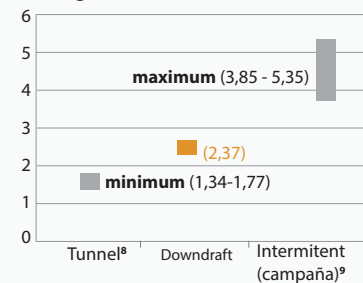
(measured at firing temperature of 900-1100 °C)

Average: 3,10 MJ/kg fired bricks or tiles  
(Range: 2.8 – 3,5 MJ/kg fired or brick or tile)

COMPARISON OF SEC OF  
DOWNDRAFT KILN WITH OTHER KILN  
TECHNOLOGIES

The downdraft kiln reports a usual SEC for intermittent kilns (SEC – 2 to 4.5 MJ/kg fired brick ), a positive aspect is the possibility to recover the heat of the combustion gases, to be used during the drying process

## MJ/kg fired bricks

DESCRIPTION ON ENERGY  
CONSUMPTION AND MAIN CAUSES OF  
HEAT LOSS

Incomplete combustion of wood and heat, losses from exhaust gases in the stack

## FINANCIAL PERFORMANCE:

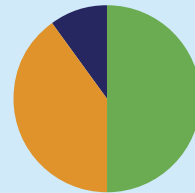
## Capital Cost of the kiln technology

Capital Cost of the kiln technology  
(for annual production capacity of 0.18 – 0.60 million bricks)  
(excluding land and working capital)

6.000 to 12.000 USD

## Capital Cost Break-up

Capital Cost Breakdown	
Material Cost	50%
Labour Cost	35%
Equipment Cost	15%
Total	100%

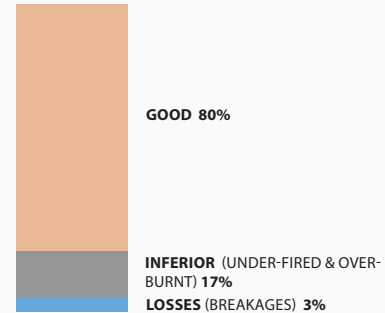


Production Capacity	800-1100 tons/year, depending on the size of ceramic processing. Example.180,000 perforated bricks of 12x20x25 cm or 600,000 perforated bricks of 8x23x12 cm	
No of Operators required	2	
Payback Period	Simple Payback	0.8 – 1.5 years
	Discounted Payback (@ 6.5%)	0.7 – 2.5 years

## PRODUCT QUALITY:

## Product quality:

(As per the local market perception)

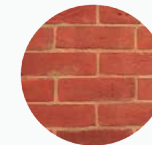


## Description on product quality

Non-uniform temperature across the vertical section of the kiln results in under-fired bricks at the floor zone and hence differences in the product quality

Types of product that can be fired in the kiln		
Solid bricks		✓
Hollow/ Perforated bricks		✓
Roof Tiles		✓
Others		

## GOOD BRICK

INFERIOR BRICK  
Under-fired and over-burnt

## OCCUPATIONAL HEALTH AND SAFETY (OHS):

Exposure to Respirable Suspended Particulate Matter<sup>5</sup>

Description about the exposure: Flue gases and particulates exhausted from the chimney and unpaved surfaces around cause a concentration of soot and dust in the surrounding environment and the workers are exposed to concentration of suspended particulate matter

Impacts: This can result in a few cases of respiratory diseases among workers.

Exposure to Thermal Stress<sup>6</sup>

Description about the exposure: Workers responsible of discharging products and fuel supply are exposed directly to heat and some radiation

Impacts: This can result in dehydration among workers.

## Risk of accidents

Description about the exposure: Danger of burning during the firing or discharging

Impacts: Risk of injuries.

Practices followed at Downdraft kiln enterprises usually do not comply with the International Labour Standards on occupational health and safety drawn up by ILO. Workers are usually exposed to thermal stress and emissions. No migratory labour issues have been identified

## 7

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## CONCLUSION &amp; REFERENCES:

Conclusion:			
Parameters		FCBTK	Comments
AIR EMISSION (G/KG FIRED BRICK)	CO <sub>2</sub>	100,9	Incomplete combustion in Downdraft Kiln results in high values of emissions. The average value of PM emission lie within the notified limit, however, some of the kilns could emit higher PM
	Black Carbon	NA	
	PM	NA	
	CO	2,96	
FUEL & ENERGY	SEC (MJ/kg fired brick)	3,10	High mass of the kiln requires additional energy.
FINANCIAL PERFORMANCE	Capital Cost (USD)	6.000 to 12.000	The low capital investment and good profit is one of the main reasons that make this kiln popular
	Production Capacity	0,18-0,60 million bricks/year	
	Simple Payback	0,8 – 1.5 years	
PRODUCT QUALITY	Types of product	All types of products	Non-uniform temperature distribution in the cross-section of the kiln results in variation in product quality
	Good Quality Product	80%	
OHS	Exposure to dust	Yes, with sawdust manipulation during burning and ash on the bricks during discharge.	Downdraft Kiln operators work under exposition to high heat
	Exposure to Thermal stress	Yes	
	Risk of accidents	Yes, low risk	

## FOR MORE INFORMATION:

## REFERENCES:

- (1) Report on 'Informe de la Quinta Quema en el Horno Prototipo' available at <http://www.redladrilleras.net>
- (2) Ibid
- (3) Heierli; Urs.; Maithel, Sameer; Fust, Walter. Brick by brick: The Herculean Task of Cleaning Up the Asian Brick Industry.
- (4) Fuel injection system and thermocouples
- (5) Report on 'Occupational health and safety study (OHSS) of brick industry in the Kathmandu valley' by Department of Environmental Sciences and Engineering (DESE), Kathmandu University, Nepal
- (6) Ibid

## ACKNOWLEDGEMENT:

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## Note:

In the initial stage of this initiative of developing factsheet on brick kiln technologies, factsheet are developed for South and South-East Asia and Latin America regions. Factsheet on brick kiln technologies of other regions will be developed over time.

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