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1 DOME/CIRCULAR KILN (ASCENDANT FLAME / DOWNDRAFT)**INTRODUCTION AND HISTORY**

This kiln has a circular shape and is a technology widely disseminated across all regions in Brazil, Colombia and Peru. The principle of the operation consists in an ascendant flame that elevates the temperature into the kiln, then the heating moves from the roof to the floor of the kiln aided by a down draft.

The combustion starts at the lateral zones of the kiln (04 or 06 burners located equidistantly), 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 go to the chimney.

The draft can be natural or forced. The fuels commonly used are logs, branches and pieces of wood.

GEOGRAPHICAL DISTRIBUTION:**TYPE OF KILN**

kiln



Intermittant

CHARACTERISTICS OF ENTERPRISES USING THIS TECHNOLOGY:

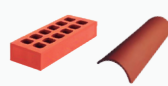
Nature of Organisation



Industrial

Level of
mechanisation

Semi-mechanised

Type of bricks/ tiles
producedHollow/perforated
bricks - TilesAnnual production capacity
of the enterprise

> 5 million bricks (medium scale)

Operational period



Round the year

**ESTIMATED N° OF OPERATIONAL ENTERPRISES AND TOTAL PRODUCTION
(USING DOME KILN)**

Country	N° of enterprises	Total Production (million bricks/tiles/year)
Brazil	~ 1,750	~ 10.300
Colombia	~ 349	~ 209
Peru	~10	~10

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1 DOME/CIRCULAR KILN (ASCENDANT FLAME / DOWNDRAFT)**DESCRIPTION & WORKING:**

Dome Kiln dimensions are: 5 - 10 meters of diameter and 2.8 - 3.2 meters of height.

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The heating produced during the combustion process rise towards the roof of the kiln.

2

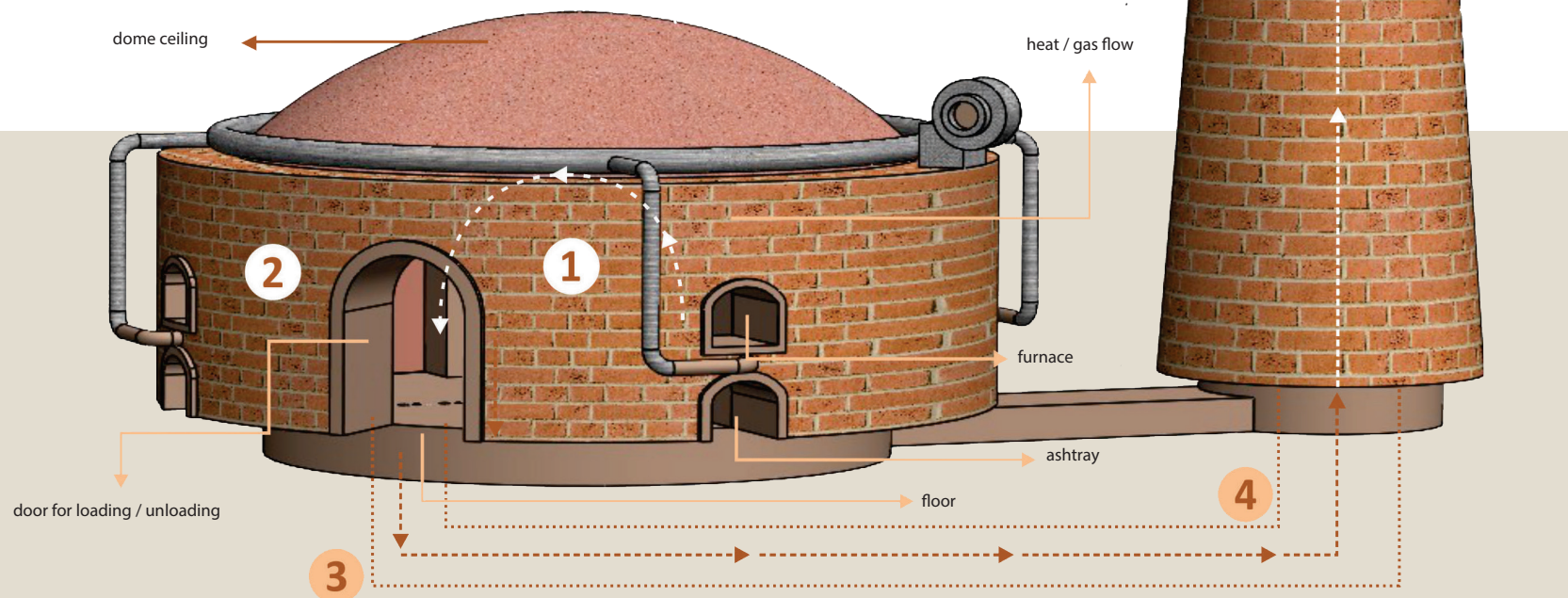
Once on the roof the gases change direction and move down through the bricks or tiles.

3

Then the gases leave the kiln through small openings on the floor.

4

Finally the gases (fumes) move toward the chimney through an underground duct; this process can be natural or forced by an exhaust.



The complete production cycle in the kiln is long: 06 - 08 hours for preheating, 36 - 48 hours for firing process and up to 03 days for cooling process; these periods depend on the type of product, raw material, type of burning process and fuel used.

The operation temperature range from 750 to 930°C, the temperature at the roof is slightly higher compared with the rest of the kiln; i.e. the temperature is slightly lower at the zone near the floor where the gases duct is located.

1

DOME/CIRCULAR KILN (ASCENDANT FLAME / DOWNDRAFT)

AIR EMISSIONS AND IMPACTS:

MEASURED EMISSION
FACTORS¹

(in g/kg fired bricks)

CO ₂	Black Carbon (BC)	Particulate Matter (PM)	CO
330 (313-360)	Not available	Not available	Not available

MEASURED PM EMISSION (mg/Nm³)

Average: 44,6 (with air/fuel injection)
243,7 (without fuel injection)

EMISSION STANDARDS

Emission standards are notified only for PM emissions

Country	PM (mg/Nm ³)
Brazil	730 (< 10 MW) 520 (between 10 and 30 MW)
Colombia	250 (NOx: 550,SOx: 550) 50 (NOx: 500,SOx: 500) for new enterprises

COMMENTS ON EMISSIONS

The values of emission standards for fixed sources depend on the thermal power rating (MW).

This kiln produces low emissions of soot (particulate matter) because the structure acts as a filter; i.e. the particulate matter is retained in the structure of the kiln and the load of bricks.

FUEL AND ENERGY:

COMMONLY USED FUELS



Biomass
(e.g. - firewood, biomass briquettes, sawdust).



Coal (dust)

SPECIFIC ENERGY CONSUMPTION² (SEC)

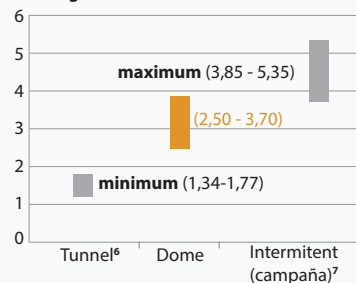
(measured at firing temperature of 900-1100 °C)

Average: 3,50 MJ/kg fired bricks or tiles
(Range: 2,5 – 3,7 MJ/kg fired brick or tile)

COMPARISON WITH OTHER KILN TECHNOLOGIES

Dome Kiln reports a usual SEC for intermittent kilns (SEC: 2 to 4 MJ/kg fired brick); a positive aspect is the possibility to recover the heat of the kiln, once the combustion process is concluded, for drying green bricks in a conditioned space.

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. Heavy structure could absorb part of the energy.

FINANCIAL PERFORMANCE:

Capital Cost of the kiln technology

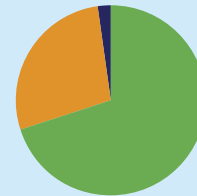
(for annual production capacity of 3 – 5 million bricks or tiles)
(excluding land and working capital cost)

30.000 to 50.000 USD*

* without fuel feeder.

Capital Cost Breakdown

Material Cost	70%
Labour Cost	28%
Equipment Cost	2%
Total	100%

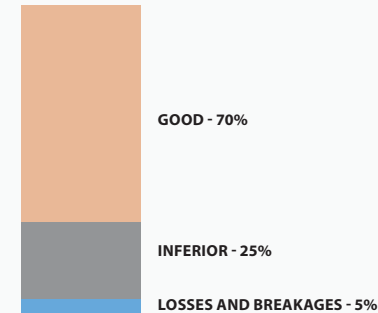


Production Capacity	25,000 to 110,000 bricks/tiles per week Main brick size: 180 x 180 x 85 mm Main tile size: 490 x 130 mm	
No of Operators required	8-10	
Payback Period	Simple Payback	0.5 – 2.0 years
	Discounted Payback (@ 6.5%)	0.7 – 3 years

PRODUCT QUALITY:

Product quality:

(As per the local market perception)

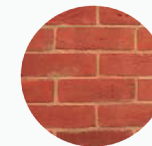


Description on product quality

Non-uniform temperature across the vertical section of the kiln results in under-fired bricks/tiles 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 Matter³

Flue gases exhausted from the chimney and unpaved surfaces around cause a very high concentration of soot and dust in the surrounding environment and the workers are exposed to high concentration of suspended particulate matter

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

Exposure to Thermal Stress⁴

Workers responsible of discharging products and fuel supply are exposed directly to heat and some radiation

This can result in dehydration among workers

Risk of accidents

Danger of burning during the firing or discharging

Risk of injuries

Compliance with ILO standards and remarks on migratory labour and conditions of labour:

Practices followed at Dome/circular kiln enterprises 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.

1

DOME/CIRCULAR KILN (ASCENDANT FLAME / DOWNDRAFT)

CONCLUSION & REFERENCES:

Conclusion:			
Parameters		Dome kiln	Comments
AIR EMISSION (G/KG FIRED BRICK)	CO2	330	Incomplete combustion in Dome Kiln results in high value 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	NA	
FUEL & ENERGY	SEC (MJ/kg fired brick)	3,50	Incomplete combustion and heat losses result in increase in the fuel consumption in Dome Kiln.
FINANCIAL PERFORMANCE	Capital Cost (USD)	30.000 to 50.000	Low capital investment and high return are one of the main reasons of the popularity of the Dome Kiln.
	Production Capacity	3-8 million bricks/year	
	Simple Payback	0,6 – 1,7 years	
PRODUCT QUALITY	Types of product	All types of product	Non-uniform temperature distribution in the cross-section of the kiln results in variation in product quality.
	Good Quality Product	60-80%	
OHS	Exposure to dust	yes	Dome Kiln operators work under exposition to high heat
	Exposure to Thermal stress	yes	
	Risk of accidents	yes	

FOR MORE INFORMATION:

REFERENCES:

References are provided as 'Endnotes'

(1) Report on 'Brick Kiln Performance Assessment' available at

http://www.unep.org/ccac/Portals/24183/docs/Brick_Kilns_Performance_Assessment.pdf

(2) Ibid.

(3) Field observation.

(4) Ibid.

(5) By its initials in Portuguese

(6) Tunnel Kiln: EELA. Manual de hornos eficientes para la industria de cerámica roja. Feb, 2015. / Greentech, SDC. Factsheets about brick kilns in South and South-East Asia. Dec, 2013.

(7) Intermitent (campana): EELA. Diagnóstico inicial del sector ladrillero, Región del Seridó en el Nordeste de Brasil. Marzo, 2011

ACKNOWLEDGEMENT:

The project team would like to acknowledge the financial support received from the Swiss Agency for Development and Cooperation for the preparation of these fact-sheets.

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.

Factsheet prepared by:

National Institute of Technology – INT⁵, Rio de Janeiro, Brazil

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Swisscontact, Lima, Peru

(EELA Program staff members)

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2 CEDAN KILN (SEMI-CONTINUOUS)

INTRODUCTION AND HISTORY

This kiln is an alternative version of the traditional Hoffman model and consists in a set of chambers (usually twelve to sixteen chambers) built in pairs to facilitate the flue gases transfer. The heat produced in a chamber is deflected to the dome (roof), then the hot gases move

down heating the bricks and leave the chamber through the openings on the floor, move across the openings in the floor and to the next chamber through holes at the bottom zone in the fixed walls which are connected to the next chamber, producing a preheating of this chamber.

This kiln produces homogeneous products due to the constant temperature of the heat that moves from one chamber to another, with a low level of losses. The draft can be natural or forced. The fuels commonly used are logs, branches and pieces of wood.

GEOGRAPHICAL DISTRIBUTION:



TYPE OF KILN

kiln



Semi-Continuous Moving Fire

CHARACTERISTICS OF ENTERPRISES USING THIS TECHNOLOGY:

Nature of Organisation



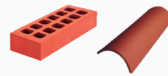
Industrial

Level of mechanisation



Semi-mechanised

Type of bricks/ tiles produced



Hollow/perforated bricks - Tiles

Annual production capacity of the enterprise



> 1 < 10 million bricks (medium scale)

Operational period



Round the year

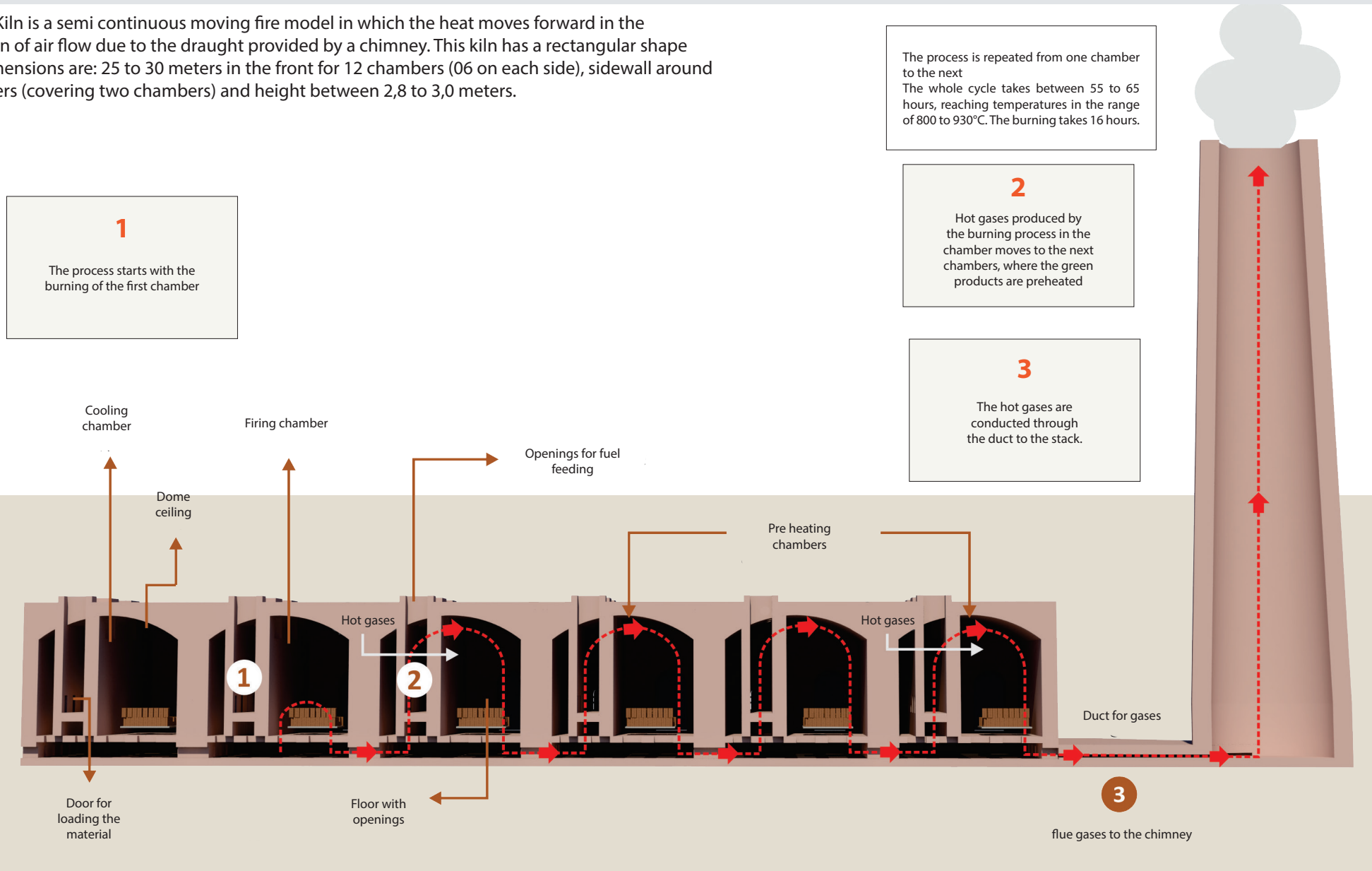
ESTIMATED N° OF OPERATIONAL ENTERPRISES AND TOTAL PRODUCTION (USING CEDAN KILN)

Country	N° of enterprises	Total Production (billion bricks/tiles/year)
Brazil	~ 150	~ 1.5

2 CEDAN KILN (SEMI-CONTINUOUS)

DESCRIPTION & WORKING:

Cedan Kiln is a semi continuous moving fire model in which the heat moves forward in the direction of air flow due to the draught provided by a chimney. This kiln has a rectangular shape and dimensions are: 25 to 30 meters in the front for 12 chambers (06 on each side), sidewall around 08 meters (covering two chambers) and height between 2,8 to 3,0 meters.



2 CEDAN KILN (SEMI-CONTINUOUS)

AIR EMISSIONS AND IMPACTS:



MEASURED EMISSION FACTORS¹

(in g/kg fired bricks)

CO ₂	Black Carbon (BC)	Particulate Matter (PM)	CO
175 (165-195)	Not available	Not available	Not available

MEASURED PM EMISSION

Average: Not available

EMISSION STANDARDS

Emission standards are notified only for PM emissions

Country	PM (mg/Nm ³)
Brazil	730 (< 10 MW) 520 (between 10 and 30 MW)

COMMENTS ON EMISSIONS

The values of the emission standards of fixed sources depend on the thermal power rating (MW) of the sources (kilns).

Soot emissions are very low because the internal design of the kiln that acts like a filter. Even though the kiln can use a continuous biomass feeding process (sawdust or chopped firewood) reducing or eliminating the soot completely.

FUEL AND ENERGY:

COMMONLY USED FUELS



Biomass
Biomass (e.g. firewood, biomass briquettes, sawdust).

SPECIFIC ENERGY CONSUMPTION² (SEC)

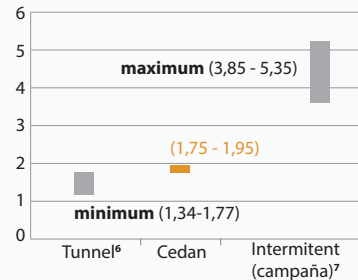
(measured at firing temperature of 900-1100 °C)

Average: 1,85 MJ/kg fired bricks or tiles
(Range: 1,75 – 1,95 MJ/kg fired/brick or tile)

COMPARISON WITH OTHER KILN TECHNOLOGIES

Cedan Kiln reports a SEC value under the range for traditional kilns (SEC – 2 to 4 MJ/kg fired brick), but the value is slightly above compared to the reported SEC values for continuous kilns (tunnel model).

MJ/kg fired bricks



DESCRIPTION ON ENERGY CONSUMPTION AND MAIN CAUSES OF HEAT LOSS

The fuel consumption is low and there is : is low PM in the flue gas.

FINANCIAL PERFORMANCE:

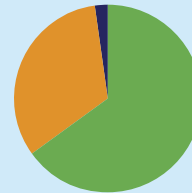
Capital Cost of the kiln technology

(for annual production capacity of 4-9 million bricks)
(excluding land and working capital cost)

200.000 to 260.000 USD (depending of the number of chambers)

Capital Cost Breakdown

Capital Cost Break-up	
Material Cost	65%
Labour Cost	33%
Equipment Cost	2%
Total	100%

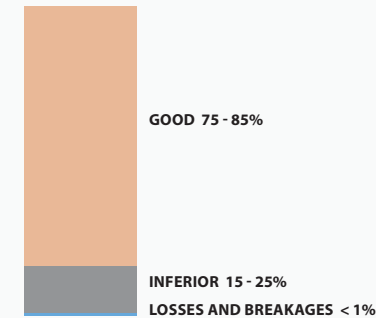


Production Capacity	200,000 bricks or tiles per week Main brick size: 180 x 180 x 85 mm Main tile size: 490 x 130 mm	
No of Operators required	6-8	
Payback Period	Simple Payback	2,5 – 3,5 years
	Discounted Payback (@ 6.5%)	2,7 – 3,8 years

PRODUCT QUALITY:

Product quality:

(As per the local market perception)

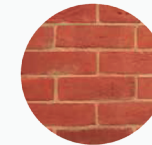


Description on product quality

Homogenous and very high 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 Matter³

Description about the exposure: some dust in the surrounding environment. Workers are exposed to high concentration of suspended particulate matter

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

Exposure to Thermal Stress⁴

Description about the exposure: The workers that are engaged in kiln activities (discharging products and fueling) 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 falling off during the bricks assembly in the kiln and/or burn

Impacts: Risk of injuries

Compliance with ILO standards and remarks on migratory labour and conditions of labour:

Practices followed at CEDAN kiln enterprises do not comply with the International Labour Standards on occupational health and safety drawn up by ILO, majority of the workers are usually exposed to thermal stress and significant risk of accidents.

No migratory labour issues have been identified.

2 CEDAN KILN (SEMI-CONTINUOUS)

CONCLUSION & REFERENCES:

Conclusion:			
Parameters		Cedan Kiln	Comments
AIR EMISSION (G/KG FIRED BRICK)	CO2	175	Cedan Kiln is a good technological option for batch production.
	Black Carbon	NA	
	PM	NA	
	CO	NA	
FUEL & ENERGY	SEC (MJ/kg fired brick)	1,85	Energy performance is good in this kiln.
FINANCIAL PERFORMANCE	Capital Cost (USD)	200.000-260.000	High capital cost is one of the difficulties.
	Production Capacity	7-8 million bricks or tiles / year	
	Simple Payback	2,5 – 3,5 years	
PRODUCT QUALITY	Types of product	All types of product	Non-uniform temperature distribution across the kiln (cross-section) can result in variation in product quality.
	Good Quality Product	80%	
OHS	Exposure to dust	yes	Cedan Kiln has some poor OHS conditions, mainly related to work exposition to heat during discharging products.
	Exposure to Thermal stress	yes	
	Risk of accidents	yes	

FOR MORE INFORMATION:

REFERENCES:

References are provided as 'Endnotes'

(1) Report on 'Brick Kiln Performance Assessment' available at

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3 MOBILE KILN

INTRODUCTION AND HISTORY

Mobile Kiln is a model in which the entire structure of the kiln can be moved using a rail system and stacked over the green bricks previously loaded for burning. The burners are coupled along the side of the kiln.

The structure of this kiln is very light weight, because it only uses ceramic fiber and steel layers. As fuel can be use biomass, gas or oil. Firewood usually employed can be chopped,

briquettes and sawdust.



GEOGRAPHICAL DISTRIBUTION:



TYPE OF KILN

kiln



Intermittent

CHARACTERISTICS OF ENTERPRISES USING THIS TECHNOLOGY:

Nature of Organisation



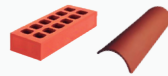
Industrial

Level of mechanisation



Mechanised

Type of bricks/ tiles produced



Hollow/perforated bricks - Tiles

Annual production capacity of the enterprise



> 10 million bricks (medium to large scale)

Operational period



Round the year

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

Country	N° of enterprises	Total Production (billion bricks/tiles/year)
Brazil	~ 100	~ 1.0
Peru	3	NA*
Bolivia	2	NA*
Paraguay	5	NA*

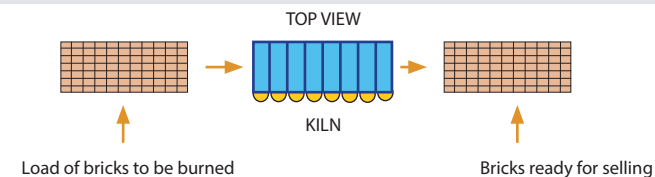
* N.A.: Not available

3

MOBILE KILN

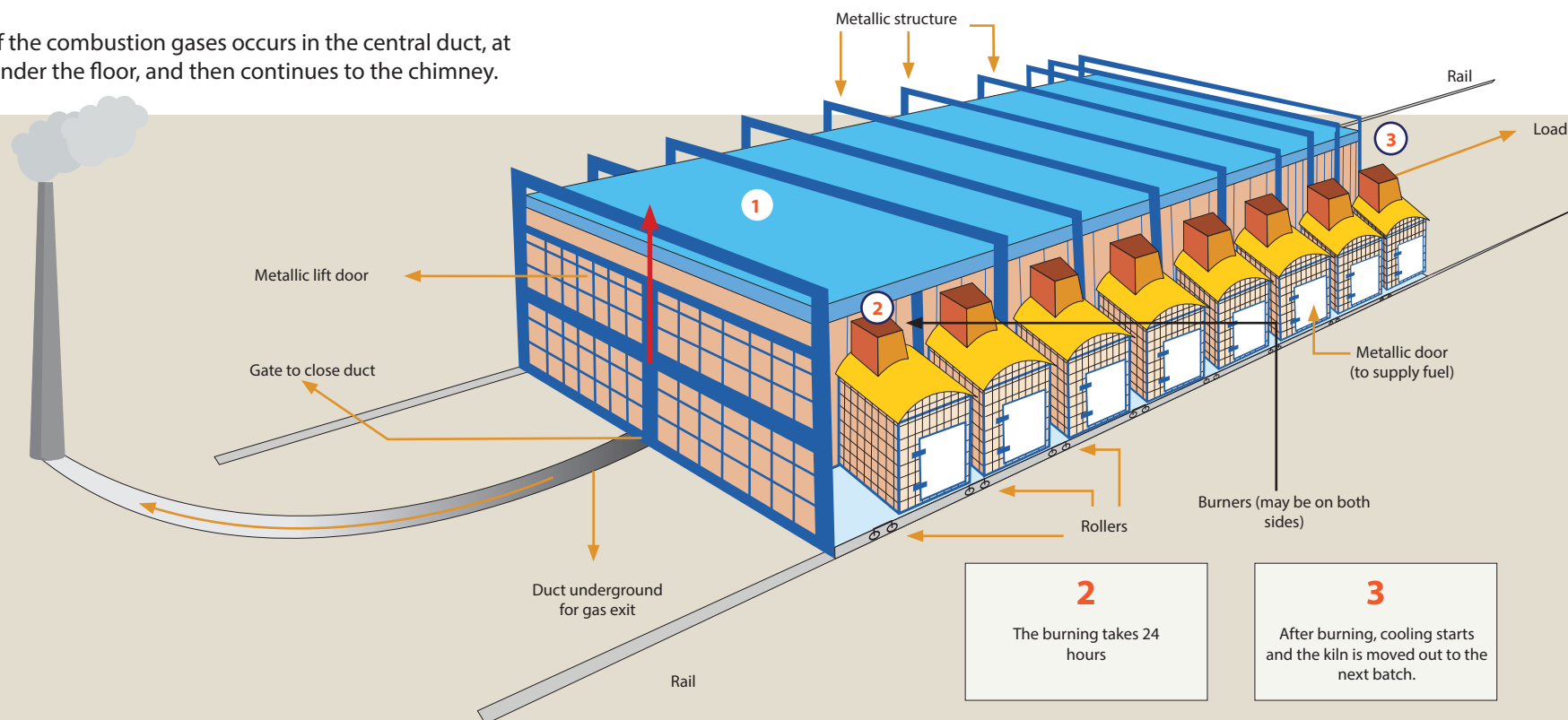
DESCRIPTION & WORKING:

- The Mobile Kiln has a rectangular shape and its dimensions can be quite variable, with width ranging from 3.4 to 9.4 m and length from 15m to 30m.
- In the Mobile Kiln the brick loading is stacked and the structure of the kiln moves along the rails on the floor with the support of pushers/handles.
- The firing cycle tends to be shorter compared with the traditional kilns, due to its lighter structure that absorbs less heat, and saves time in charging and discharging of materials.
- The structure is made basically of metal and insulated with ceramic fiber.
- The output of the combustion gases occurs in the central duct, at the bottom under the floor, and then continues to the chimney.



1

Batch of bricks is stacked on the floor and the batch is moved toward to it.



3

MOBILE KILN

AIR EMISSIONS AND IMPACTS:

MEASURED EMISSION
FACTORS¹

(in g/kg fired bricks)

CO ₂	Black Carbon (BC)	Particulate Matter (PM)	CO
170 (estimated)	Not available	Not available	Not available

MEASURED PM EMISSION

Average: Not available

EMISSION STANDARDS

Emission standards are notified only for PM emissions

Country	PM (mg/Nm ³)
Brazil	730 (< 10 MW) 520 (between 10 and 30 MW)

COMMENTS ON EMISSIONS

The values of the emission standards of fixed sources depend on the thermal power rating (MW) of the sources (kilns).

This type of kiln usually produces low emissions of soot (particulate matter) due to the continuous fuel feed system and a better adjusting of the relation air/fuel.

FUEL AND ENERGY:

COMMONLY USED FUELS



Biomass
Biomass (eg. biomass briquettes, sawdust).

SPECIFIC ENERGY CONSUMPTION²
(SEC)

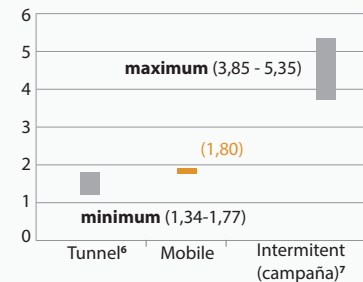
(measured at firing temperature of 750-950 °C)

Average: 1,80 MJ/kg fired bricks/tiles (estimated)

COMPARISON WITH OTHER KILN
TECHNOLOGIES

Mobile Kiln reports a SEC value under the range for traditional kilns (SEC – 2 to 4 MJ/kg fired brick), mainly because of the firing cycles are shorter and the lightweight and low density properties of the kiln, reducing the needs to heat the kiln itself.

MJ/kg fired bricks

DESCRIPTION ON ENERGY
CONSUMPTION AND MAIN CAUSES OF
HEAT LOSS

Heat losses in the flue gas.

FINANCIAL PERFORMANCE:

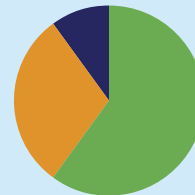
Capital Cost of the kiln technology

(for annual production capacity of 6 – 12 million bricks)
(excluding land and working capital cost)

70.000 to 400.000 USD

Capital Cost Breakdown

Capital Cost Break-up	
Material Cost	60%
Labour Cost	30%
Equipment Cost	10%
Total	100%

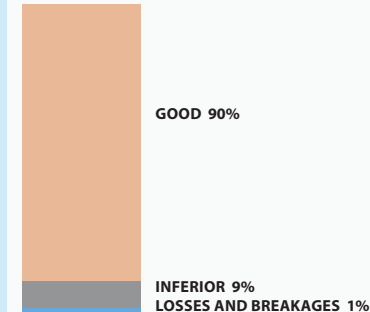


Production Capacity	150,000 to 250,000 bricks/tiles per week Main brick size: 180 x 180 x 85 mm Main tile size: 490 x 130 mm	
No of Operators required	6	
Payback Period	Simple Payback	3.5 - 4.5 years
	Discounted Payback (@ 6.5%)	3.8 - 5.0 years

PRODUCT QUALITY:

Product quality:

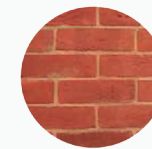
(As per the local market perception)



Description on product quality
Good quality product is expected.

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 Matter³

Description about the exposure: low level of dust in the surrounding area.

No exposure risk has been identified.

Exposure to Thermal Stress⁴

Description about the exposure: burner operators are exposed directly to heat and some radiation.

No exposure risk has been identified.

Risk of accidents

Description about the exposure: danger of falling off during the bricks assembly in the kiln.

No risk has been identified.

Compliance with ILO standards and remarks on migratory labour and conditions of labour:

Practices followed at mobile kiln enterprises tend to comply with the International Labour Standards on occupational health and safety drawn up by ILO. Because of mechanisation of the processes, the working conditions of workers are relatively better with less exposure to emissions, minimal exposure to thermal stress and reduced risk of accidents. No migratory labour issues have been identified.

3

MOBILE KILN

CONCLUSION & REFERENCES:

Conclusion:			
Parameters		Mobile Kiln	Comments
AIR EMISSION (G/KG FIRED BRICK)	CO2	170 (estimated)	Low atmospheric emissions.
	Black Carbon	NA	
	PM	NA	
	CO	NA	
FUEL & ENERGY	SEC (MJ/kg fired brick)	1,80	Low fuel consumption in Mobile Kiln.
FINANCIAL PERFORMANCE	Capital Cost (USD)	70.000 to 400.000	High capital investment and high return of investment.
	Production Capacity	6-24 million bricks/year	
	Simple Payback	0,6 – 1,7 years	
PRODUCT QUALITY	Types of product	All types of product	Uniform temperature distribution across the kiln cross-section.
	Good Quality Product	>90%	
OHS	Exposure to dust	minimal	Mobile Kiln has good OHS conditions, mainly related to work exposition and emissions gases.
	Exposure to Thermal stress	minimal	
	Risk of accidents	minimal	

FOR MORE INFORMATION:

REFERENCES:

References are provided as 'Endnotes'

(1) Report on 'Brick Kiln Performance Assessment' available at

http://www.unep.org/ccac/Portals/24183/docs/Brick_Kilns_Performance_Assessment.pdf

(2) Ibid.

(3) Field observation.

(4) Ibid.

(5) By its initials in Portuguese

(6) Tunnel Kiln: EELA. Manual de hornos eficientes para la industria de cerámica roja. Feb, 2015. / Greentech, SDC. Factsheets about brick kilns in South and South-East Asia. Dec, 2013.

(7) Intermitent (campana): EELA. Diagnóstico inicial del sector ladrillero, Región del Seridó en el Nordeste de Brasil. Marzo, 2011

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Factsheet prepared by:

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4 PAULISTINHA KILN

INTRODUCCION AND HISTORY

This model basically consists of pairs of rectangular chambers with walls and dome roof constructed with conventional bricks. The door for loading and unloading material is located in the lateral wall. The internal floor of the chambers is constructed of bricks leaving openings between the pieces which are connected to the chimney through underground ducts.

Paulistinha Kiln has burners (four or six) at the lateral walls, generally constructed in pairs; moving the fire from the floor to the roof and then the heat moves down burning the bricks and the flue gases are conducted to the duct stacked at the floor of the rear wall of the kiln and then moved to the chimney. The fuels commonly used are logs, branches and pieces of wood.

This kiln presents a slight deficiency related to the heat distribution, that determines hot and cold spots in certain zones and, consequently, different quality products; however, it is a widely disseminated model in all Brazilian regions due to the low construction cost.



GEOGRAPHICAL DISTRIBUTION:



TYPE OF KILN

kiln



Intermittant

CHARACTERISTICS OF ENTERPRISES USING THIS TECHNOLOGY:

Nature of Organisation



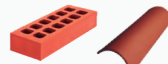
Industrial

Level of
mechanisation



Semi-mechanised

Type of bricks/ tiles
produced



Hollow/perforated
bricks - Tiles

Annual production capacity
of the enterprise



> 1 & < 10 million bricks
(medium scale)

Operational period



Round the year

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

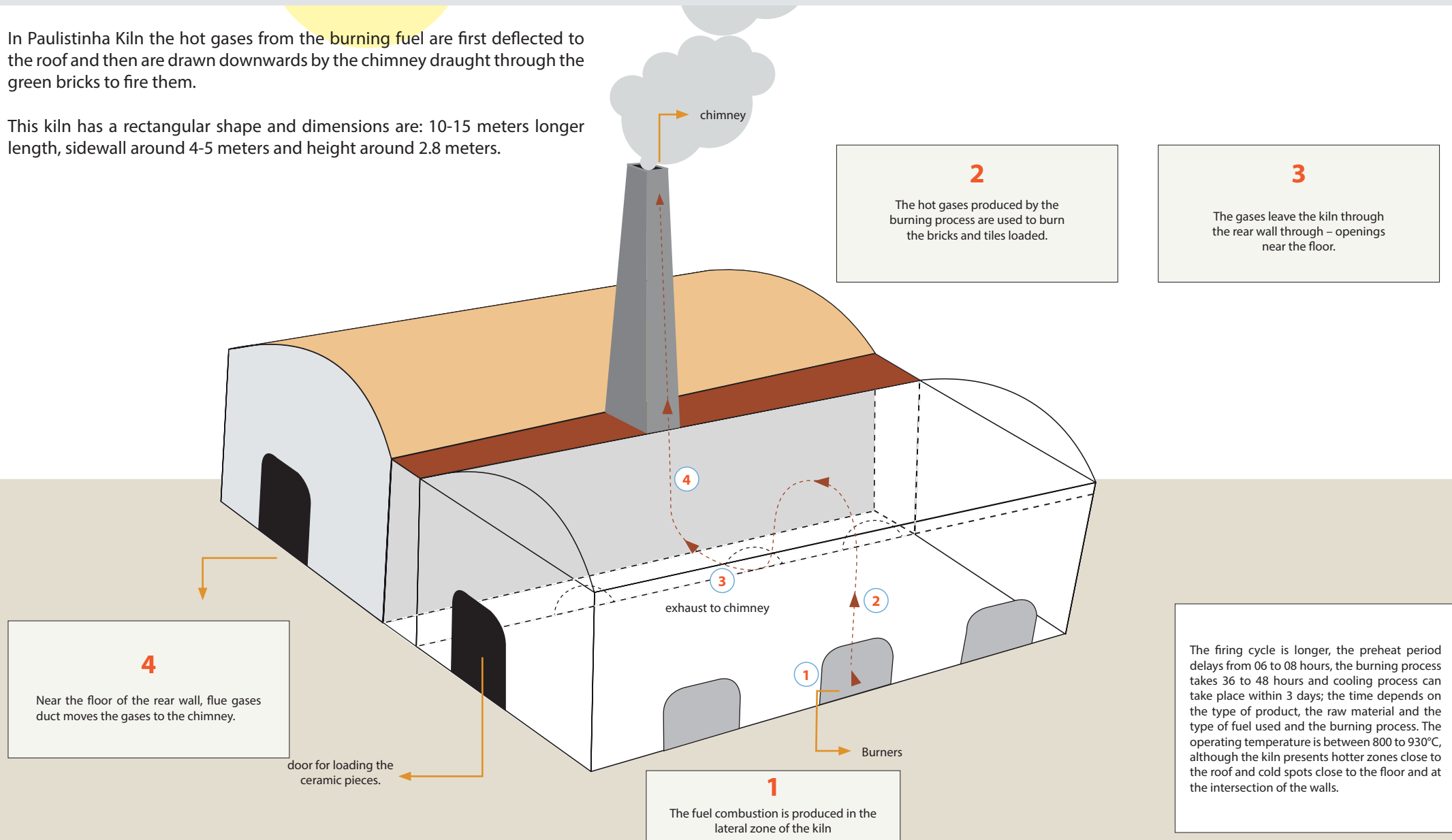
Country	N° of enterprises	Total Production (billion bricks/tiles/year)
Brazil	~ 1,100	~ 6,2

4 PAULISTINHA KILN

DESCRIPTION & WORKING:

In Paulistinha Kiln the hot gases from the burning fuel are first deflected to the roof and then are drawn downwards by the chimney draught through the green bricks to fire them.

This kiln has a rectangular shape and dimensions are: 10-15 meters longer length, sidewall around 4-5 meters and height around 2.8 meters.



4

PAULISTINHA KILN

AIR EMISSIONS AND IMPACTS:

MEASURED EMISSION
FACTORS¹

(in g/kg fired bricks)			
CO ₂	Black Carbon (BC)	Particulate Matter (PM)	CO
380 (360-400)	Not available	Not available	Not available

MEASURED PM EMISSION

Average: Not available

EMISSION STANDARDS

Emission standards are notified only for PM emission

Country	PM (mg/Nm ³)
Brazil	730 (< 10 MW) 520 (between 10 and 30 MW)

COMMENTS ON EMISSIONS

Its values of the emission standards of fixed sources depend on the thermal power rating (MW) of the sources (kilns).

This kiln usually produces soot (particulate matter) mainly during the intermittent firewood feeding process, when the kiln is fed with the wood occurs lack of the combustion air, which causes an increasing of the emissions soot. After 10 to 15 minutes the ratio of air/fuel stabilizes and emissions are reduced until the next feeding process.

FUEL AND ENERGY:

COMMONLY USED FUELS



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

SPECIFIC ENERGY CONSUMPTION²
(SEC)

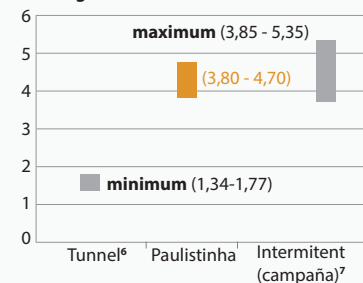
(measured at firing temperature of 900-1100 °C)

Average: 4,0 MJ/kg fired bricks/tiles
(Range: 3,8 – 4,7 MJ/kg fired/brick or tile)

COMPARISON WITH OTHER KILN
TECHNOLOGIES

Paulistinha Kiln presents a slightly higher SEC value compared with other intermittent kilns (SEC – 2 to 4 MJ/kg fired brick) due mainly to its structure.

MJ/kg fired bricks

DESCRIPTION ON ENERGY
CONSUMPTION AND MAIN CAUSES OF
HEAT LOSS

Incomplete combustion of wood, heat losses in the exhaust gases and intermittent cycle (batch cycle).

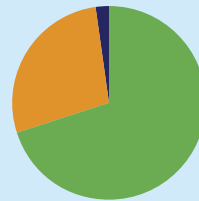
FINANCIAL PERFORMANCE:

Capital Cost of the kiln technology
(for annual production capacity of 3 – 5 million bricks)
(excluding land and working capital cost)

28.000 to 46.000 USD

Capital Cost Breakdown

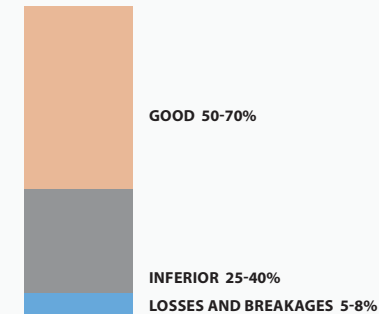
Capital Cost Break-up	
Material Cost	70%
Labour Cost	28%
Equipment Cost	2%
Total	100%



Production Capacity	50.000 to 75.000 bricks / tiles per week Main brick size: 180 x 180 x 85 mm Main tile size: 490 x 130 mm	
No of Operators required	8-10	
Payback Period	Simple Payback	0.7 – 2.1 years
	Discounted Payback (@ 6.5%)	0.9 – 3.0 years

PRODUCT QUALITY:

Product quality:
(As per the local market perception)

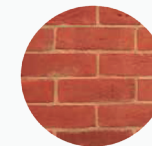


Description on product quality

Non-uniform temperature across the horizontal-section of the kiln results in under-fired bricks/tiles at the rear 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 Matter³

Description about the exposure: Flue gases exhausted from the chimney cause a very high concentration of dust in the surrounding environment and the workers are exposed to high concentration of a suspended particulate matter.

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

Exposure to Thermal Stress⁴

Description about the exposure: The workers that are engaged in kiln activities (discharging products and fueling) are exposed directly to heat and some radiation.

Impacts: This can result in dehydration among workers.

Risk of accidents

Danger of burning during firing or discharging.

Impacts: Risk of injuries.

Practices followed at Paulistinha kiln enterprises do not comply with the International Labour Standards on occupational health and safety drawn up by ILO, majority of the workers are usually exposed to emissions and thermal stress.

No migratory labour issues have been identified.

4 PAULISTINHA KILN

CONCLUSION & REFERENCES:

Conclusion:			
Parameters		Paulistinha Kiln	Comments
AIR EMISSION (G/KG FIRED BRICK)	CO2	380	Incomplete combustion in kiln results in high value of emissions, mainly after wood feeding.
	Black Carbon	NA	
	PM	NA	
	CO	NA	
FUEL & ENERGY	SEC (MJ/kg fired brick)	4,0	Incomplete combustion and heat losses result in increase in the fuel consumption in Paulistinha Kiln.
FINANCIAL PERFORMANCE	Capital Cost (USD)	28.000-48.000	Low capital investment and high return is one of the main reasons for popularity of Paulistinha technology.
	Production Capacity	3-8 million bricks/year	
	Simple Payback	0,7 – 2,1 years	
PRODUCT QUALITY	Types of product	All types of product	Non-uniform temperature distribution across the kiln cross-section results in variation in product quality.
	Good Quality Product	60 %	
OHS	Exposure to dust	yes	Paulistinha Kiln complies partially OHS conditions.
	Exposure to Thermal stress	yes	
	Risk of accidents	yes	

FOR MORE INFORMATION:

REFERENCES:

References are provided as 'Endnotes'

(1) Report on 'Brick Kiln Performance Assessment' available at

http://www.unep.org/ccac/Portals/24183/docs/Brick_Kilns_Performance_Assessment.pdf

(2) *Ibid.*

(3) Field observation.

(4) *Ibid.*

(5) By its initials in Portuguese

(6) Tunnel Kiln: EELA. Manual de hornos eficientes para la industria de cerámica roja. Feb, 2015. / Greentech, SDC. Factsheets about brick kilns in South and South-East Asia. Dec, 2013.

(7) Intermitent (campanha): EELA. Diagnóstico inicial del sector ladrillero, Región del Seridó en el Nordeste de Brasil. Marzo, 2011

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y la Cooperación COSUDE

5 MULTI CHAMBERS KILN

INTRODUCTION AND HISTORY

This model was adapted to the local context with good results. The operational principle is very similar to the Hoffman kiln, the only difference is the fuel consumption that is slightly higher due to the large mass of the kiln¹.

One of the advantages is the possibility to produce different products (in each chamber) with a superior and uniform quality since the product is not in direct contact with the flame. In Colombia the kiln usually is operated with coal.

Front view of the kiln



GEOGRAPHICAL DISTRIBUTION:



TYPE OF KILN

kiln



Continuous

CHARACTERISTICS OF ENTERPRISES USING THIS TECHNOLOGY:

Nature of Organisation



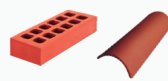
Industrial

Level of mechanisation



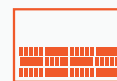
Semi-mechanised

Type of bricks/ tiles produced



Solid bricks
Hollow/perforated
bricks

Annual production capacity of the enterprise



> 1 & < 10 million bricks
(medium scale)

Operational period



Round the year

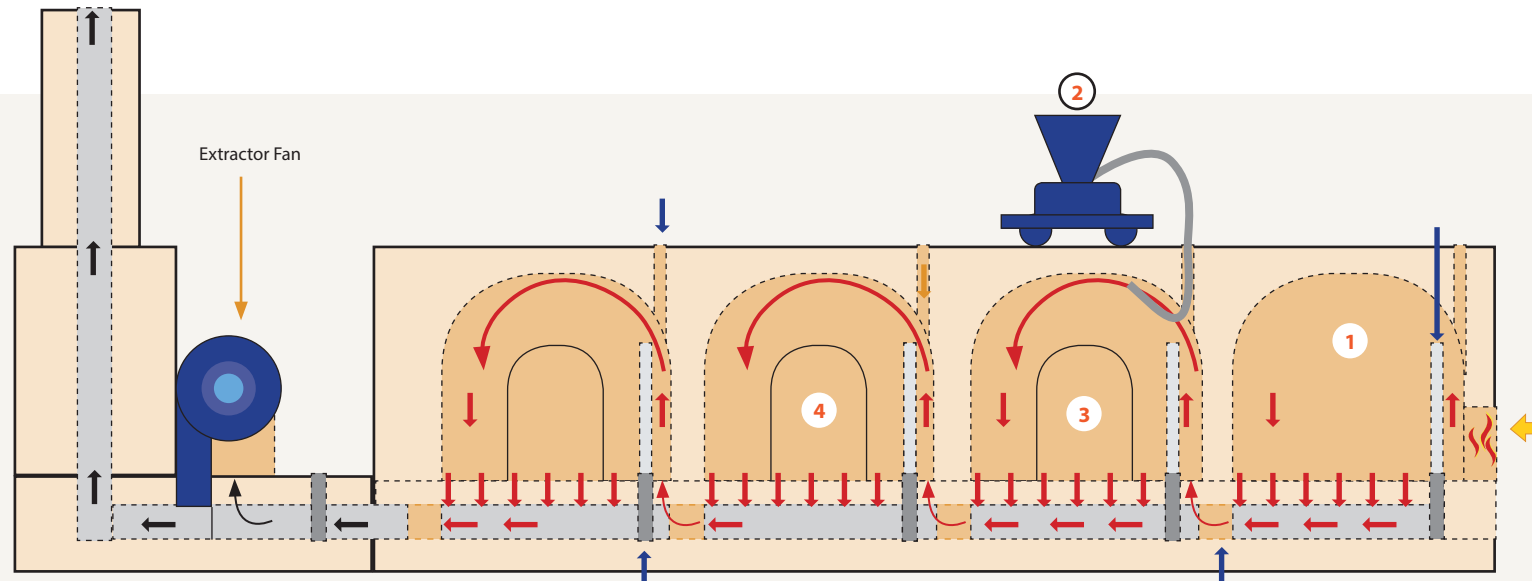
ESTIMATED N° OF OPERATIONAL ENTERPRISES AND TOTAL PRODUCTION (USING MULTICHAMBER KILN)

Country	N° of enterprises	Total Production (million bricks or tiles year)
Colombia	12	~ 26,07

5 MULTI CHAMBERS KILN

DESCRIPTION & WORKING:

- Multi Chambers Kiln brings the possibility to use the heating energy in the interconnected chambers; this kiln also permits to recover the heat from the chamber to dry the green bricks, reducing the drying period. The recovery of the heat is made with a specially designed duct and a forced draught that drives the air through the chambers containing the bricks burned, the process takes place during the cooling stage.
- Cooling. This process can take between 6 to 12 hours per chamber supported with cooling fans until it reaches a temperature close to room temperature.
- The complete production cycle of the kiln is long and depends on the number of chambers, type of product, raw material and quality of fuel used.



1

Ignition and preheat. Begins at the first chamber, passing the residual heat of the combustion gases go to the adjacent chamber to preheat and complete the drying of the green bricks.

2

Fuel dosage. Each chamber has a sluice for the combustion, during this process the fuel supply is made on the top of the kiln using dosing equipment with supply hoses.

3

Firing of the bricks. When the first chamber reaches a temperature of 950 - 1050°C, the second chamber will be at 300 - 450°C, temperature to start the combustion on this chamber.

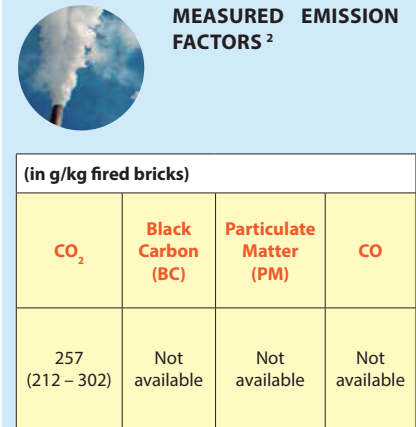
4

The third chamber will use the residual heat of the second chamber, and so on until complete the series of chambers.

5

MULTI CHAMBERS KILN

AIR EMISSIONS AND IMPACTS:



MEASURED PM EMISSION

Average: 76,7 mg/Nm³

EMISSION STANDARDS

Emission standards are notified only for PM emissions

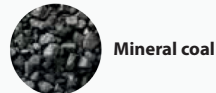
Country	PM (mg/Nm ³)
Colombia	250 mg/Nm ³

COMMENTS ON EMISSIONS

Air infiltration on the lateral areas could increase of the percentage of oxygen; in this case the emissions will not meet the national standards. It is recommended to use refractory material on the domes of the chamber in order to improve the conditions of the heat flux into the combustion zone. This kiln produces low emissions of soot (particulate matter).

FUEL AND ENERGY:

COMMONLY USED FUELS

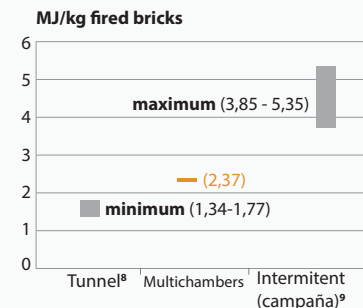
SPECIFIC ENERGY CONSUMPTION⁴
(SEC)

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

Average: 2,37 MJ/kg fired bricks or tiles

COMPARISON WITH OTHER KILN TECHNOLOGIES

Multi Chambers Kiln reports a usual SEC for intermittent kilns (SEC – 2 to 4 MJ/kg fired brick); these kilns operated semi continuously and more efficiently than the intermittent kilns.



DESCRIPTION ON ENERGY CONSUMPTION AND MAIN CAUSES OF HEAT LOSS

Thermal losses could occur in the cracks on the doors and lateral walls of the kiln.

FINANCIAL PERFORMANCE:

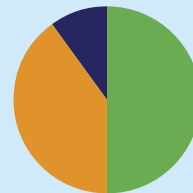
Capital Cost of the kiln technology

(for annual production capacity of 1 - 3 million bricks)
(excluding land and working capital cost)

100.000 - 170.000 USD

Capital Cost Breakdown

Capital Cost Breakdown	
Material Cost	50%
Labour Cost	40%
Equipment Cost	10%
Total	100%

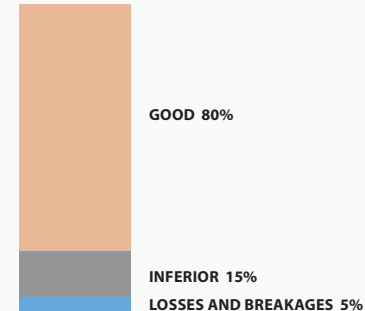


Production Capacity	120,000 bricks/tiles per month Main brick size: 300 x 200 x 100 mm	
No of Operators required	3-5	
Payback Period	Simple Payback	0.5 – 2.0 years
	Discounted Payback (@ 6.5%)	1 – 3 years

PRODUCT QUALITY:

Product quality:

(As per the local market perception)

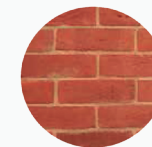


Description on product quality

Non-uniform temperature across the vertical section of the kiln results in under-fired bricks/tiles at the bottom zone and hence differences in the quality of the products.

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 Matter⁷

Flue gases exhausted from the chimney or cracks on the walls unpaved surfaces around cause concentration of soot and dust in the surrounding environment and the workers are exposed to concentration of suspended particulate matter.

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

Exposure to Thermal Stress⁶

Workers responsible of discharging products and fuel supply are exposed directly to heat and some radiation.

This can result in dehydration among workers.

Risk of accidents

Danger of fall down during fuel supply on the top of the kiln.
Electric shock by operating the equipment.

Risk of injuries.

Practices followed at Multichambers kiln enterprises do not comply with the International Labour Standards on occupational health and safety drawn up by ILO, majority of the workers are usually exposed to thermal stress and emissions from the chimney. Significant risk of accidents during fuel supply on the roof of the kiln. No migratory labour issues have been identified.

5

MULTI CHAMBERS KILN

CONCLUSION & REFERENCES:

Conclusion:			
Parameters		FCBTK	Comments
AIR EMISSION (G/KG FIRED BRICK)	CO2	257	The average value of PM emissions is within the notified limit (Colombian Norms)
	Black Carbon	NA	
	PM	NA	
	CO	NA	
FUEL & ENERGY	SEC (MJ/kg fired brick)	2,37	The value can be reduced when the kiln is operated continuously
FINANCIAL PERFORMANCE	Capital Cost (USD)	170.000	Is a model for producers with a capacity of 2 – 5 ton/hour, is an interesting alternative due to the short recovery period for the investment and the option to add more chambers. The production can be increased in 15-25%.
	Production Capacity	600 ton bricks/month	
	Simple Payback	0,5 – 2 years	
PRODUCT QUALITY	Types of product	Solids, hollow and perforate bricks and tiles.	The bricks produced meet the requirements established in the Colombian Technical Norm for construction products.
	Good Quality Product	80%	
OHS	Exposure to dust	yes	This model of kiln improves labor conditions compared with other intermittent technologies; the risk of accidents is reduced in 50% due to its ease of operation
	Exposure to Thermal stress	yes	
	Risk of accidents	yes	

FOR MORE INFORMATION:

REFERENCES:

References are provided as 'Endnotes'

- (1) CAEM 2011, Technical report of appropriate technologies for the reconversion of the artisan brick sector
- (2) Report on 'Brick Kiln Performance Assessment' available at http://www.unep.org/ccac/Portals/24183/docs/Brick_Kilns_Performance_Assessment.pdf
- (3) CAEM 2014, Evaluation of the multi chamber kiln emissions in El Santuario Factory, Nemocón – Cundinamarca
- (4) *Ibid.*
- (5) Field observation.
- (6) *Ibid.*
- (7) By its initials in Spanish
- (8) Tunnel Kiln: EELA. Manual de hornos eficientes para la industria de cerámica roja. Feb, 2015. / Greentech, SDC. Factsheets about brick kilns in South and South-East Asia. Dec, 2013.
- (9) Intermittent (campaña): EELA. Diagnóstico inicial del sector ladrillero, Región del Seridó en el Nordeste de Brasil. Marzo, 2011

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Agencia Suiza para el Desarrollo
y la Cooperación COSUDE

6 ZIGZAG KILN

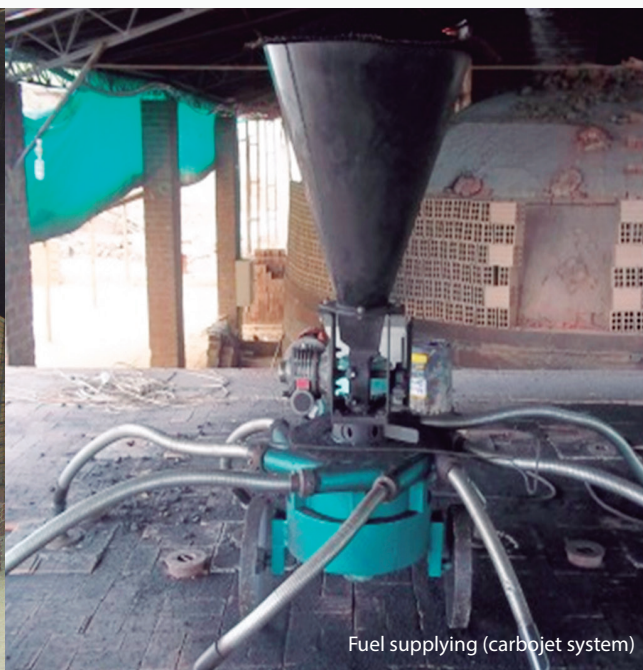
INTRODUCCION AND HISTORY

One of the most recognized alternative model of the Hoffman Kiln is the zigzag model' or Bühler Kiln, a semi continuous and moving fire kiln consisting on 10 to 30 chambers; one of the more relevant characteristics of the Zigzag Kiln is the segmented displacement of the fire from one chamber to the next, chambers are parallel and the length of the two side walls is larger than the central walls cut and separated

in the space where the duct of gases and heating recovery zone are located. At small and medium scale requires less space than the traditional Hoffman model and the fire movement through the chamber is horizontal. One of the main characteristic of the Zigzag Kiln is the fuel injection, at the beginning of the firing process, the supply process is manual and carried out through the burners

located over the front part, then the supply process is made at the roof of the kiln using pneumatic equipment (carbojet), injecting the fuel using hoses and air pressure. The fuel commonly used is coal. In some cases, mixing with biomass (specifically coffee husk) has been reported.

GEOGRAPHICAL DISTRIBUTION:



Fuel supplying (carbojet system)

TYPE OF KILN

kiln



Continuous Moving Fire

CHARACTERISTICS OF ENTERPRISES USING THIS TECHNOLOGY:

Nature of Organisation



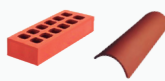
Industrial

Level of mechanisation



Semi-mechanised

Type of bricks/ tiles produced



Hollow/perforated bricks

Annual production capacity of the enterprise



> 1 & < 10 million bricks (medium scale)

Operational period



Round the year

ESTIMATED N° OF OPERATIONAL ENTERPRISES AND TOTAL PRODUCTION (USING ZIG ZAG KILN)

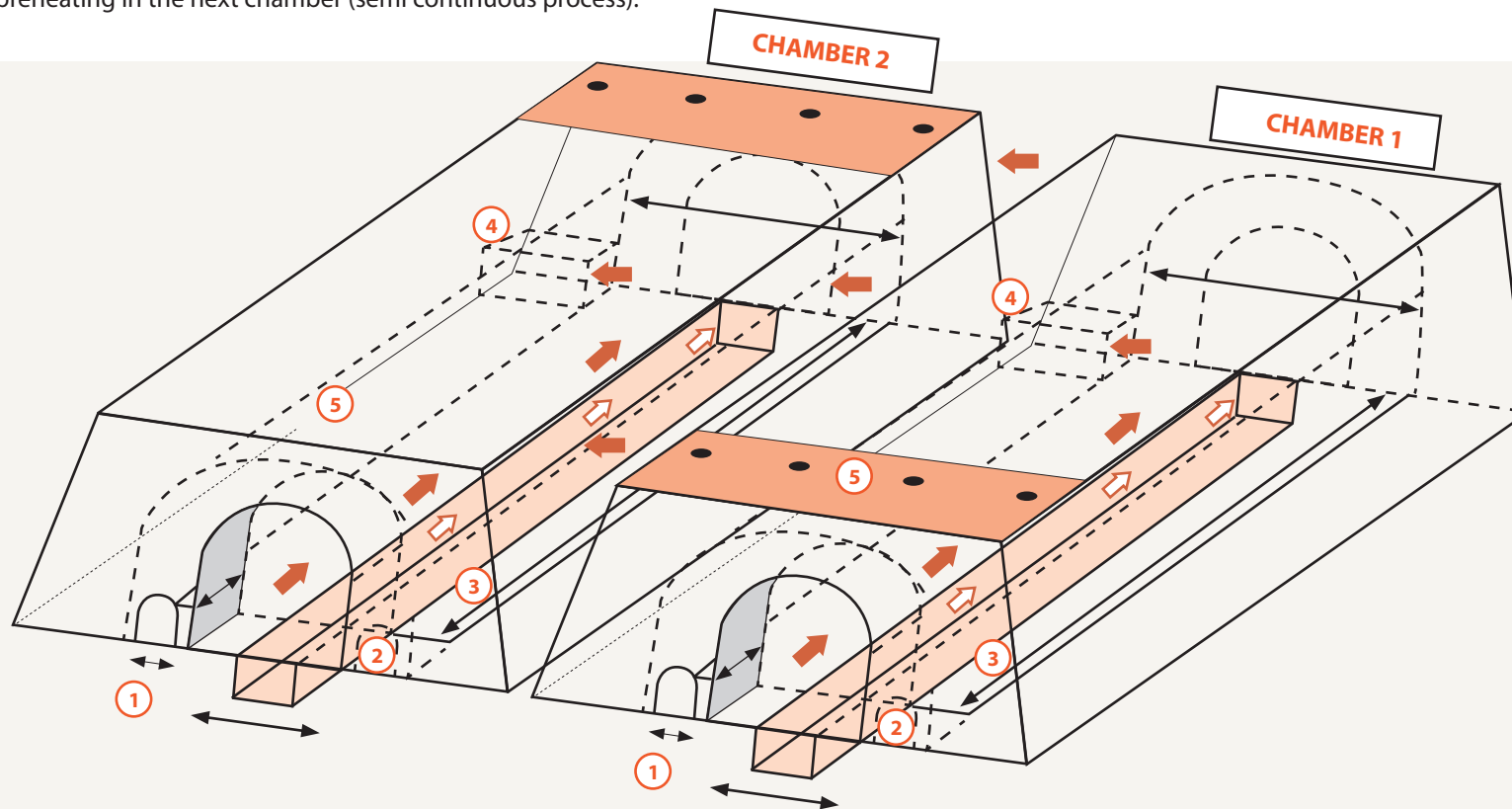
Country	N° of enterprises	Total Production (Million bricks/tiles/year)
Colombia	5	~ 10,0

6

ZIGZAG KILN

DESCRIPTION & WORKING:

- Zigzag Kiln consists on parallel chambers with tunnel shape and a dome roof; the ducts are located over the roof of the kiln. The fire moves between the chambers through the openings used to supply the fuel. The firing process is produced due to the horizontal displacement of the heating along the kiln (forced draught).
- Then the processes described in items 03 to 05 are repeated in the second chamber. The whole process is repeated from one chamber to the next.
- Once the heating is transferred to the next chamber and the optimal firing temperature is reached, the cooling process in the chamber with the fired bricks is started. Usually this process is supported by industrial fans to accelerate the cooling and to reduce operation time.
- During the firing process in a chamber, the operators can start the cooling process and downloading products in the previous chamber, as well as the loading of the pieces for preheating in the next chamber (semi continuous process).



1

At the first stage, the kiln is manually ignited using the frontal burners; the process can take 06 to 08 hours until reach a temperature between 200 and 300°C. During this period the gases duct is completely sealed.

2

Once the elevation of the temperature starts, the fuel is supplied mechanically with the carbojet (coal feeder); during this stage the temperature can reach a range between 900 to 1.000°C in the firing zone.

3

Once the temperature threshold is reached, the coal feeder keeps the temperature so the heating is distributed along the chamber using the carbojet device; during this process, gases duct is opened a 20%.

4

When 70% of the firing process has been completed in the first chamber, the gases duct is closed, and both duct for firing and duct of gases on the second chamber are opened.

5

Once the firing process is concluded in the first chamber, part of the injection hoses of the coal feeder are placed over the power line of the second chamber, increasing the supplying frequency to transfer the heating to this chamber. When the temperature threshold is reached, the rest of the hoses are placed over the fuel supply openings in the second chamber.

6

ZIGZAG KILN

AIR EMISSIONS AND IMPACTS:

MEASURED EMISSION
FACTORS²

(in g/kg fired bricks)

CO ₂	Black Carbon (BC)	Particulate Matter (PM)	CO
Not available	Not available	Not available	Not available

MEASURED PM EMISSION

Average: Not available

EMISSION STANDARDS

Emission standards are notified only for PM emissions

Country	PM (mg/Nm ³)
Colombia	250 mg/Nm ³

COMMENTS ON EMISSIONS

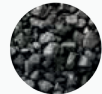
Physical chemical conditions of coal, fuel storage and supplying process have a direct incidence in the combustion process, if these aspects are not adequately controlled higher emission levels could be produced as well as lower energy efficiency.

FUEL AND ENERGY:

COMMONLY USED FUELS



Biomass



Mineral coal

SPECIFIC ENERGY CONSUMPTION³
(SEC)

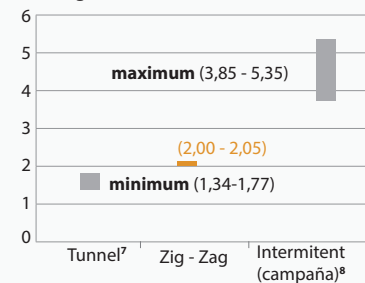
(measured at firing temperature of 900-1100 °C)

Average: 2,04 MJ/kg fired bricks
(Range: 2,0 – 2,05 MJ/kg fired brick)

COMPARISON WITH OTHER KILN
TECHNOLOGIES

Zigzag Kiln efficiency depends on the number of chambers, compared with intermittent kilns (for example, Dome Kilns) this model is more efficient in approximately 40% (1 - 2 MJ/Ton); but compared with other continuous kilns (Hoffman, Chambers or Tunnel) is less efficient in 40% (1 - 1.1 MJ/Ton)

MJ/kg fired bricks

DESCRIPTION ON ENERGY
CONSUMPTION AND MAIN CAUSES OF
HEAT LOSS

Some losses could be reported mainly due to the inadequate practices in sealing the kiln and non controlled fuel supplying.

FINANCIAL PERFORMANCE:

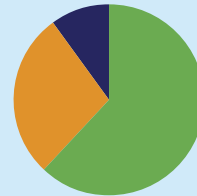
Capital Cost of the kiln technology

(for annual production capacity of ~2 million bricks)
(excluding land and working capital cost)

165.000 USD

Capital Cost Breakdown

Capital Cost Breakdown	
Material Cost	62%
Labour Cost	28%
Equipment Cost	10%
Total	100%

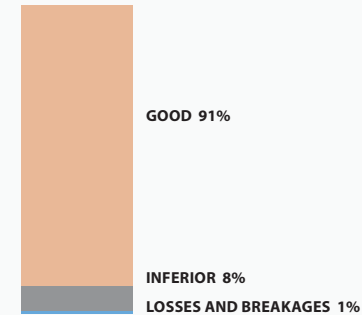


Production Capacity	170,000 bricks per month Main brick size: 300 x 200 x 100 mm	
No of Operators required	8-10	
Payback Period	Simple Payback	0.5 – 2.0 years
	Discounted Payback (@ 6.5%)	1.0 – 3.0 years

PRODUCT QUALITY:

Product quality:

(As per the local market perception)



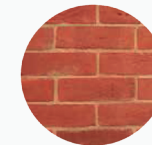
Description on product quality

Assuming optimal conditions and proper fuel feeding, products are homogeneous and have a good quality; however, some products placed on the heating zone could be affected.

It is not recommended to fired tiles due to the thermal behavior in the interior of the kiln that is optimal when pieces are placed leaving a space between the bricks

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 Matter⁴

Flue gases exhausted from the chimney and unpaved surfaces around cause concentration of soot and dust in the surrounding environment and the workers are exposed to concentration of suspended particulate matter.

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

Exposure to Thermal Stress⁵

Workers responsible of discharging products and fuel feeding are exposed directly to heat and some radiation.

This can result in dehydration among workers.

Risk of accidents

Danger of fall down during fuel supply on the roof of the kiln.
Electric shock during the operation of the feeding equipment.

Risk of injuries.

Practices followed at Zig-zag kiln enterprises do not comply with the International Labour Standards on occupational health and safety drawn up by ILO, majority of the workers are usually exposed to thermal stress and emissions from the chimney. Significant risk of accidents during fuel supply on the roof of the kiln. No migratory labour issues have been identified.

6

ZIGZAG KILN

CONCLUSION & REFERENCES:

Conclusion:			
Parameters		FCBTK	Comments
AIR EMISSION (G/KG FIRED BRICK)	CO2	Not available	The average value of PM emissions is within the notified limit (Colombian Norms)
	Black Carbon	NA	
	PM	NA	
	CO	NA	
FUEL & ENERGY	SEC (MJ/kg fired brick)	2,04	Energy consumption could be reduced in approximately 40 % when the kiln operates continuously.
FINANCIAL PERFORMANCE	Capital Cost (USD)	165.000	The production capacity can be increased in 10 to 15% with an income increase around 50.000,00 USD per year due to less use of fuel.
	Production Capacity	2,1 million bricks/year	
	Simple Payback	0,5 -2,0 years	
PRODUCT QUALITY	Types of product	solid and hollow bricks	The bricks produced meet the requirements established in the Colombian Technical Norm for construction products.
	Good Quality Product	91%	
OHS	Exposure to dust	yes	This model of kiln improves labor conditions compared with other intermittent technologies; the risk of accidents is reduced in 50% due to its ease of operation.
	Exposure to Thermal stress	yes	
	Risk of accidents	yes	

FOR MORE INFORMATION:

REFERENCES:

References are provided as 'Endnotes'

- (1) L. L. F. Rojas Gómez, et. al. Technological conversion of the firing process in a brick enterprise, 2003. Cited in the study elaborated by CAEM to define the appropriate technology under a conversion process for artisan producers, 2011
- (2) Report on 'Brick Kiln Performance Assessment' available at http://www.unep.org/ccac/Portals/24183/docs/Brick_Kilns_Performance_Assessment.pdf
- (3) *Ibid.*
- (4) Field observation.
- (5) *Ibid.*
- (6) By its initials in Spanish
- (7) Tunnel Kiln: EELA. Manual de hornos eficientes para la industria de cerámica roja. Feb, 2015. / Greentech, SDC. Factsheets about brick kilns in South and South-East Asia. Dec, 2013.
- (8) Intermittent (campaña): EELA. Diagnóstico inicial del sector ladrillero, Región del Seridó en el Nordeste de Brasil. Marzo, 2011

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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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