Firing the Future: How Cleaner Brick Production Can Reshape Brick Production Can Reshape South Asia’s Air and Climate

A new analysis based on the first direct emission measurements from the region's kilns reveals a clear path to significant climate and health benefits.

Based on the findings of Weyant, C., et al. (2014). *Emissions from South Asian Brick Production*. Environmental Science & Technology.

South Asia’s brick industry is a cornerstone of development and a major source of pollution.

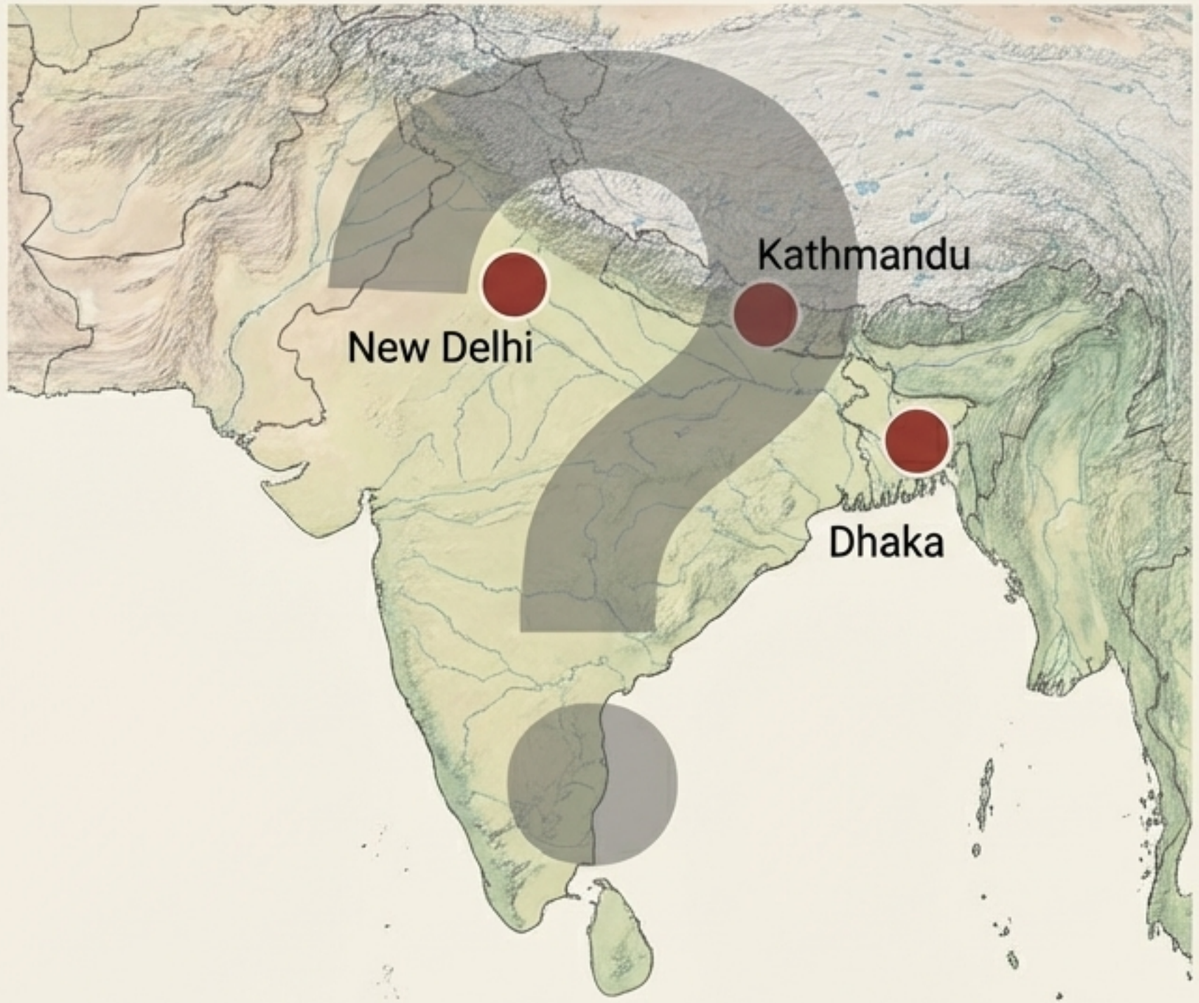
- **87%** of the world’s 1.5 trillion bricks are made in Asia.
- Over **20%** are produced in South Asia (India, Pakistan, Bangladesh, Nepal).

Production is dominated by traditional kilns burning coal or biomass with **no pollution controls.**

These kilns are a primary driver of **poor air quality.**

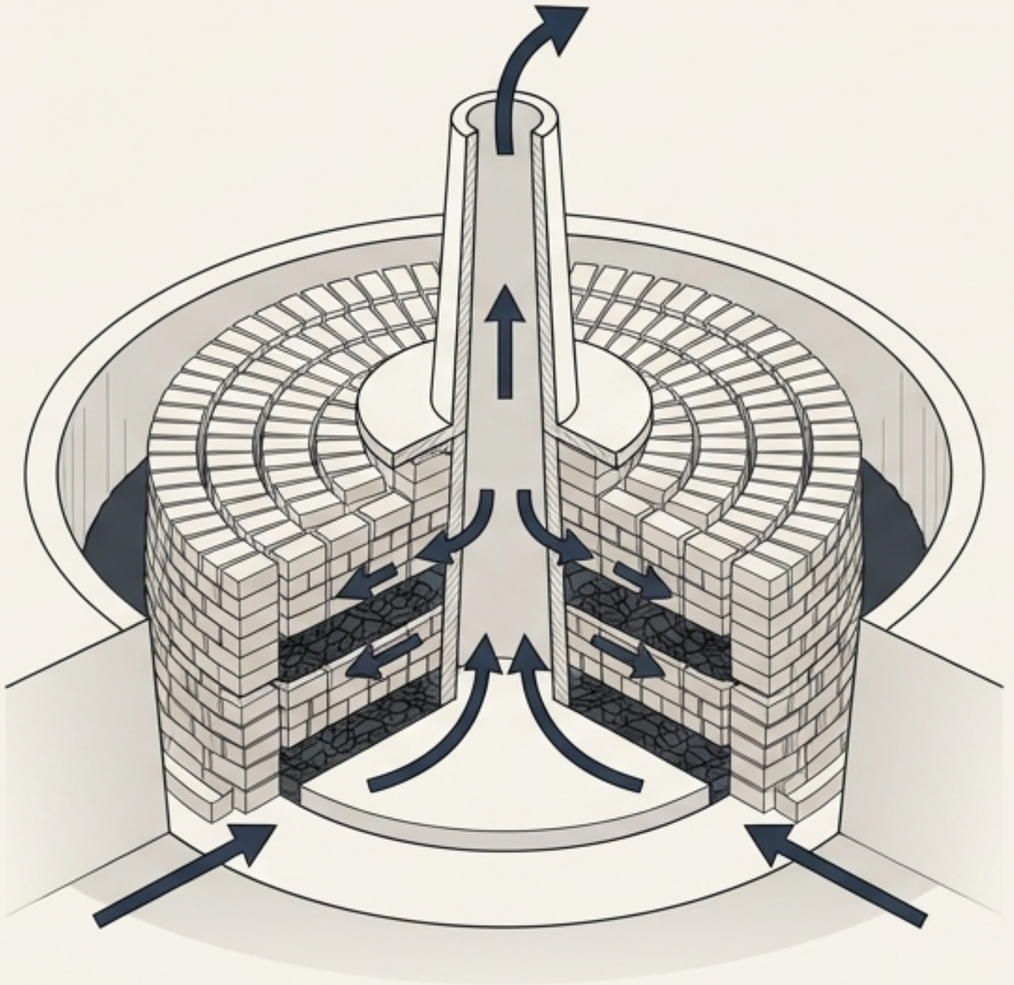
Example: In the Kathmandu valley, brick kilns are estimated to be responsible for about **28% of PM10 concentration.**

Global recommendations to modernize kilns were based on estimates, not direct measurements.



- **The Problem:** There were no previous direct measurements of Black Carbon (BC) from brick kilns in South Asia.
- **The Consequence:** Influential bodies like UNEP and the U.S. EPA based recommendations on ***estimated*** emission factors.
- **The Contribution:** This study filled the critical knowledge gap by performing the first comprehensive, direct measurements on 13 representative kilns across six different technologies.

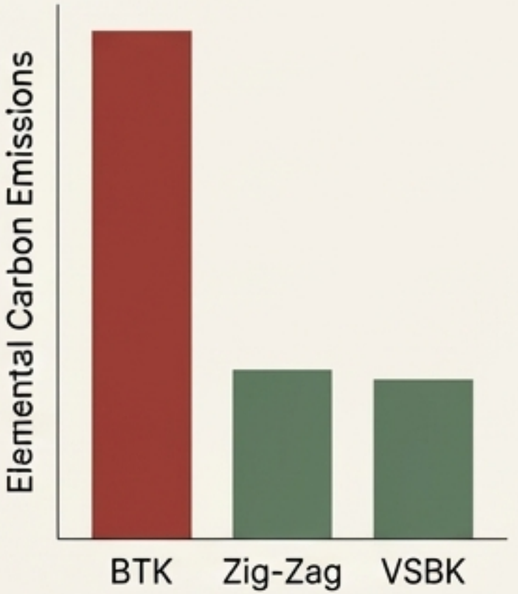
The region’s dominant technology, the Bull’s Trench Kiln (BTK), is the highest emitter of warming particles.



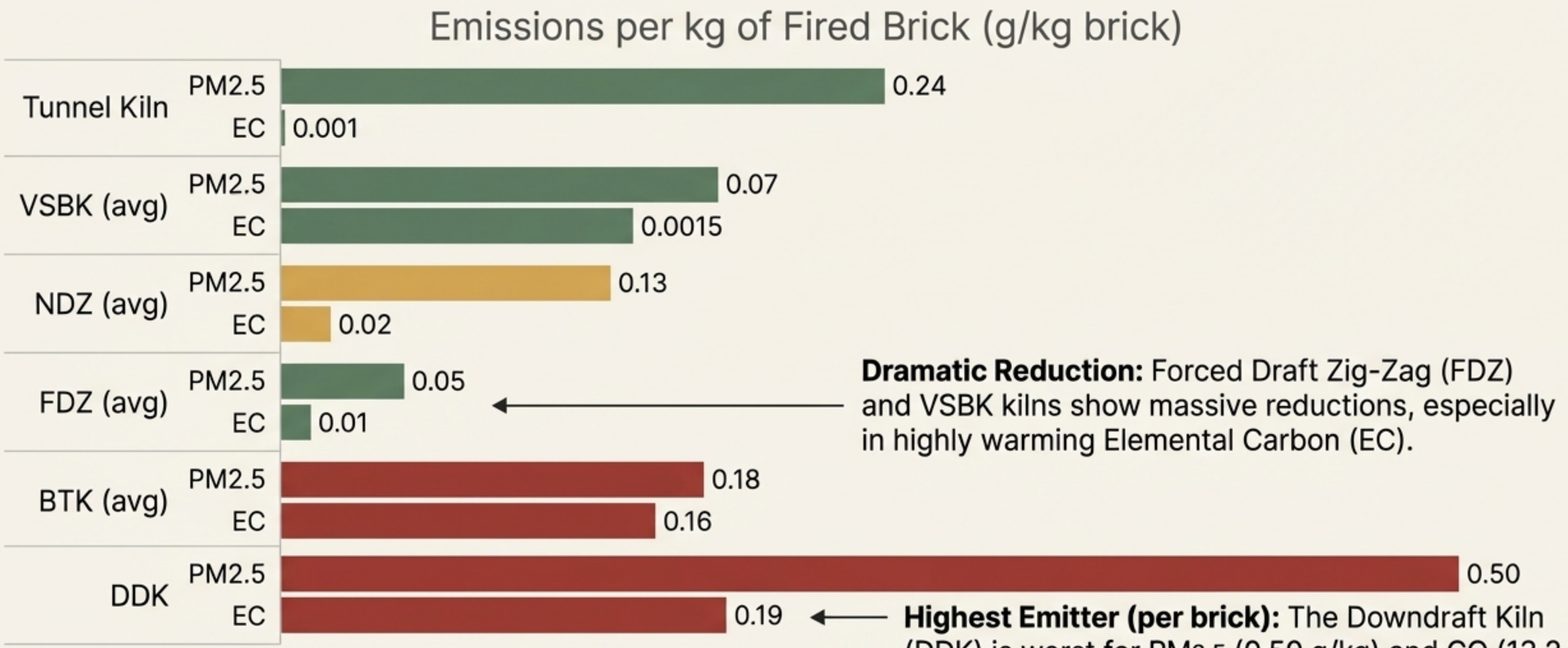
Dominance: The BTK produces approximately 70% of the bricks in India.

Key Finding 1: BTKs were the highest emitters of Elemental Carbon (EC) among all kilns tested, measured both per unit of fuel and per unit of energy.

Key Finding 2 (The Critical Detail): The particles from BTKs have an extremely high EC-to-Total-Carbon ratio of 0.91–0.96. This composition is more similar to diesel engine exhaust than typical biomass smoke, making its emissions particularly potent for atmospheric warming.



Direct measurements reveal a clear hierarchy: improved technologies slash key pollutants by an order of magnitude.

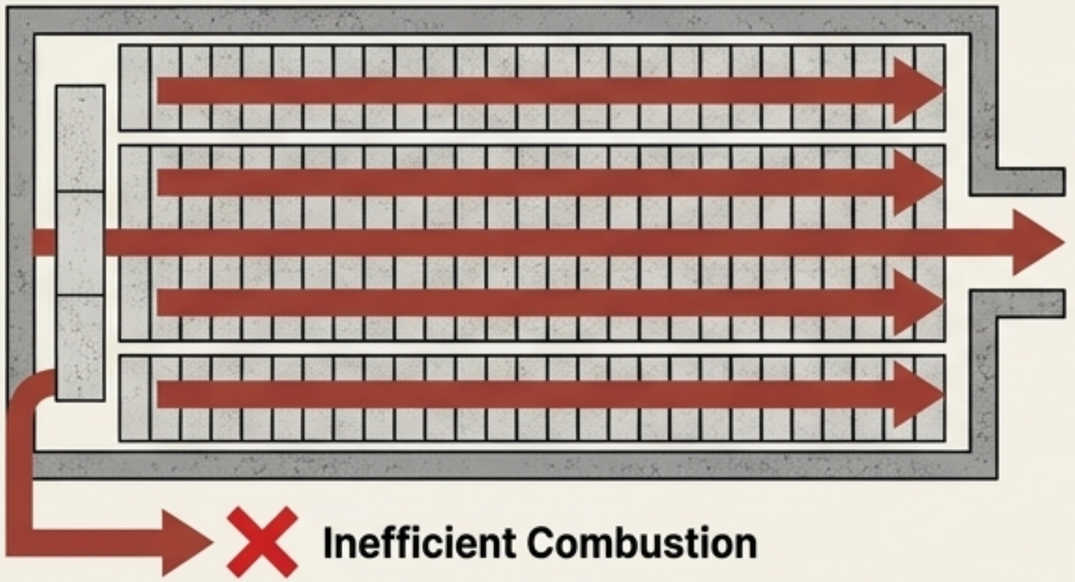


Dramatic Reduction: Forced Draft Zig-Zag (FDZ) and VSBK kilns show massive reductions, especially in highly warming Elemental Carbon (EC).

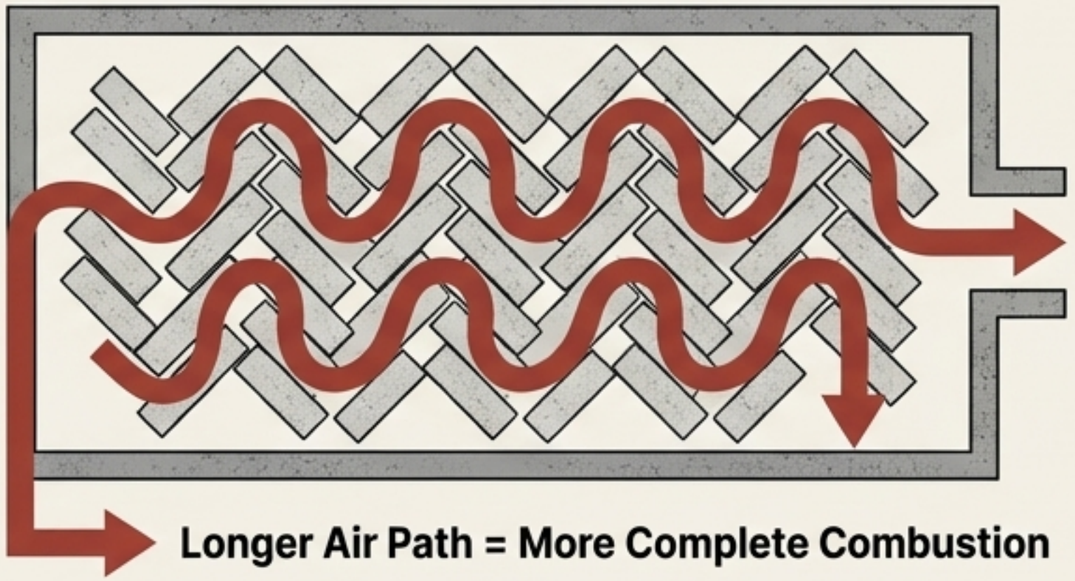
Highest Emitter (per brick): The Downdraft Kiln (DDK) is worst for $PM_{2.5}$ (0.50 g/kg) and CO (13.2 g/kg) due to extreme energy inefficiency.

The Zig-Zag kiln, a structural modification of the BTK, is a proven, low-emission, and viable upgrade path.

Bull's Trench Kiln (BTK) Airflow



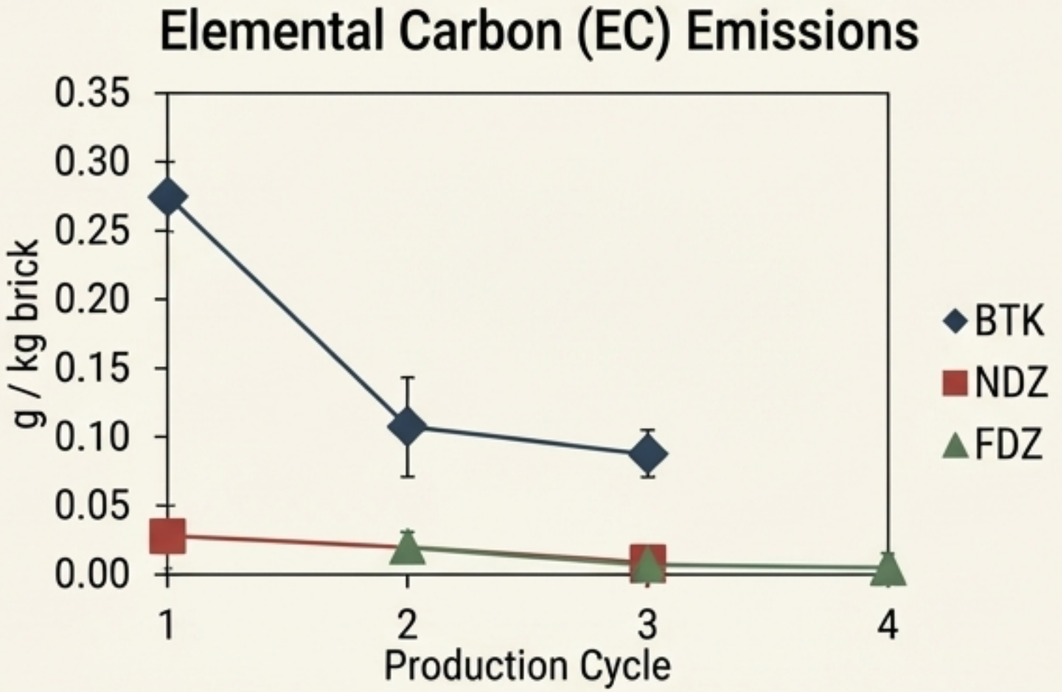
Zig-Zag Kiln Airflow

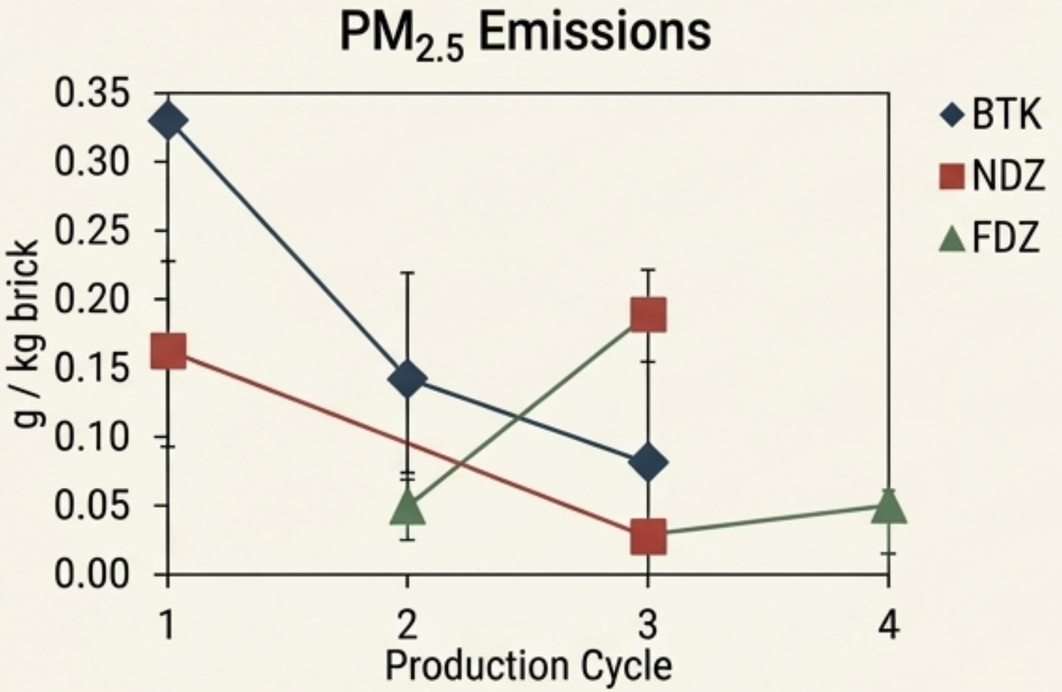


Proven Performance: Compared to BTKs, Zig-Zag kilns show statistically significant reductions in CO, EC, and particle absorption. The Forced Draft (FDZ) variant also shows statistically lower PM2.5 emissions.

The Strategic Advantage: Because the Zig-Zag is a modification of the BTK structure (changing the brick stacking pattern), it represents a highly practical conversion path for the ~70% of kilns that are BTKs.

Kiln emissions are not constant; they are highest at the beginning of the production season.

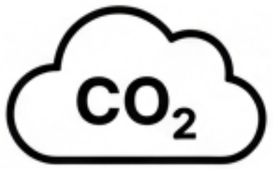




- **The Finding:** Measurements taken during the first operational 'cycle' of the season showed significantly higher $PM_{2.5}$ and EC emissions compared to measurements taken in later cycles.
- **The Reason:** This is likely due to moisture accumulated in the kiln structure during the monsoon season being driven off during the initial firings.
- **The Implication:** For accurate national inventories and effective regulation, performance must be assessed over an entire season, not just through spot-checks.

Annually, South Asia's brick industry emits particulate matter comparable to the entire regional transportation sector.

Total Annual Emissions from South Asian Brick Production



Carbon Dioxide (CO2)

120 Tg

Carbon Monoxide (CO)

2.5 Tg

Particulate Matter (PM2.5)

0.19 Tg

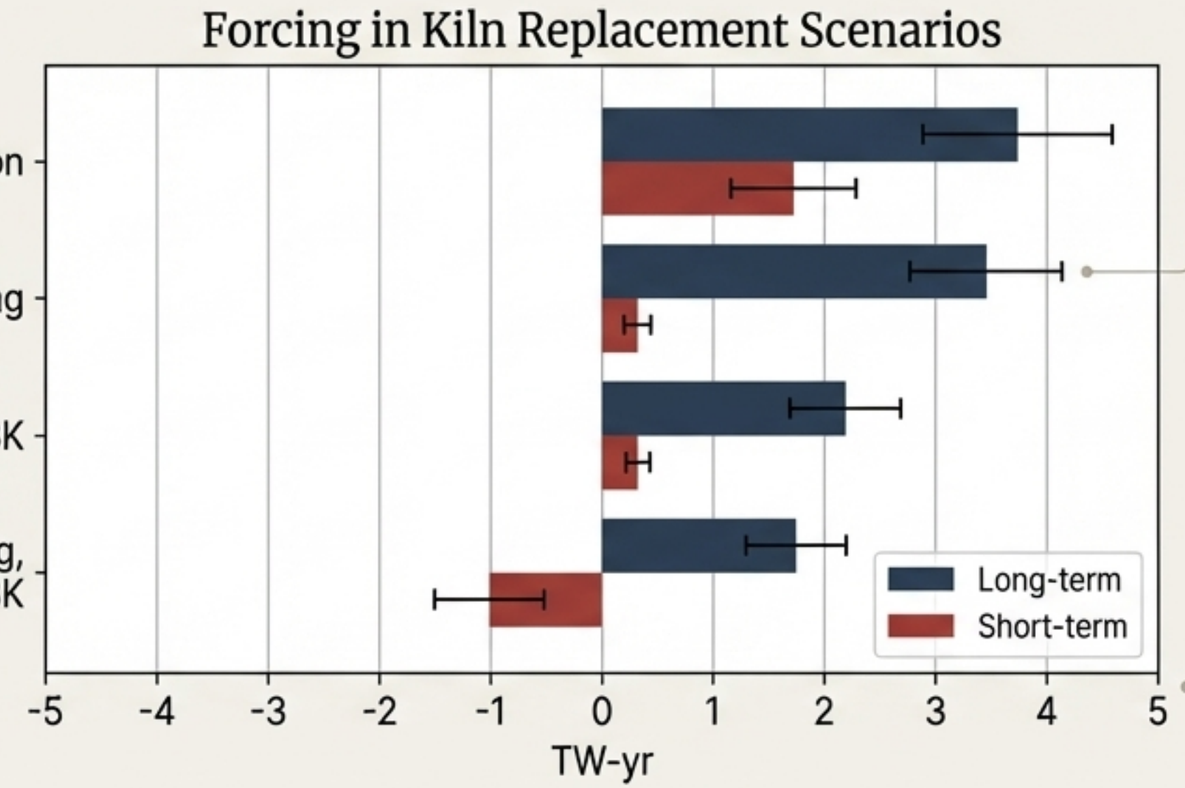
Elemental Carbon (EC)

0.12 Tg

*Context: Similar in magnitude to PM2.5 **emissions from the entire South Asian transportation sector** (0.26 Tg).

Converting to modern kilns would create an immediate and dramatic reduction in climate warming from the brick industry.

Four scenarios: from the current situation to a full technological transition. (1)

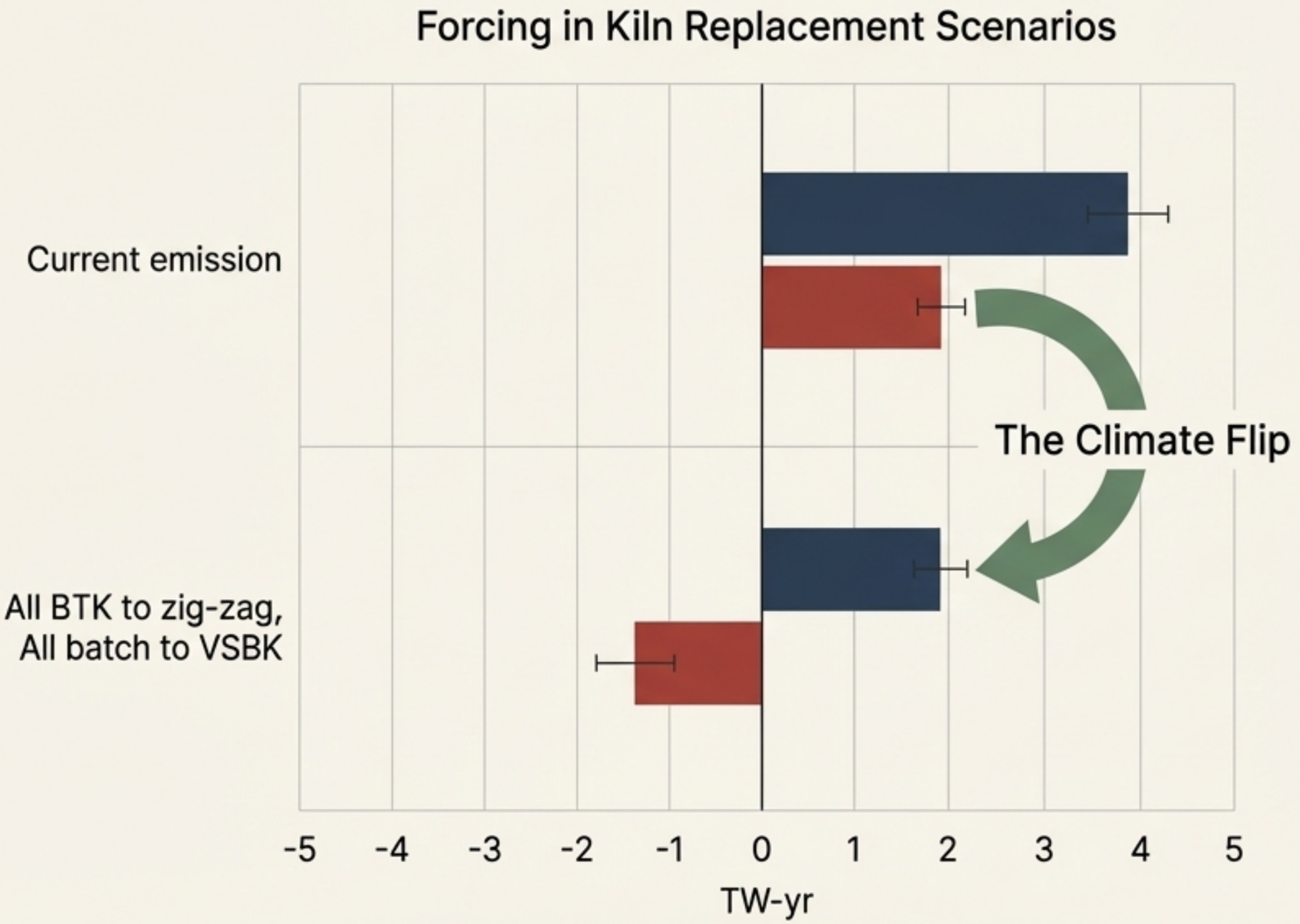


(2) Red bars show "Short-term" forcing (immediate impact from aerosols like soot). Blue bars show "Long-term" forcing (100-year impact from greenhouse gases).

(3) Positive values indicate warming; negative values indicate cooling.

The chart shows the total climate effect (integrated over 100 years) of one year's emissions. Transitioning away from BTKs and traditional batch kilns drastically reduces both short-term and long-term warming.

A full transition could flip the industry's short-term climate impact from significant warming to net cooling.



- **Step 1: BTK to Zig-Zag:** This conversion alone would reduce short-term warming forcing by 60%.
- **Step 2: Batch to VSBK:** This conversion would reduce short-term forcing by two-thirds.
- **The Ultimate Goal:** After a full conversion of both kiln types, the industry's total short-term emissions would likely have a net *cooling* effect (largely due to sulfur emissions reflecting sunlight), reducing the total short-term forcing by 70%.

Long-term (navy blue #2C3E50)
Short-term (brick red #A93F38)

The evidence is clear: We have a major problem, a proven technology, and a transformative opportunity.

The Problem is Confirmed

Traditional kilns, especially the dominant BTK, are massive sources of highly-warming black carbon, with an emission profile similar to diesel exhaust.

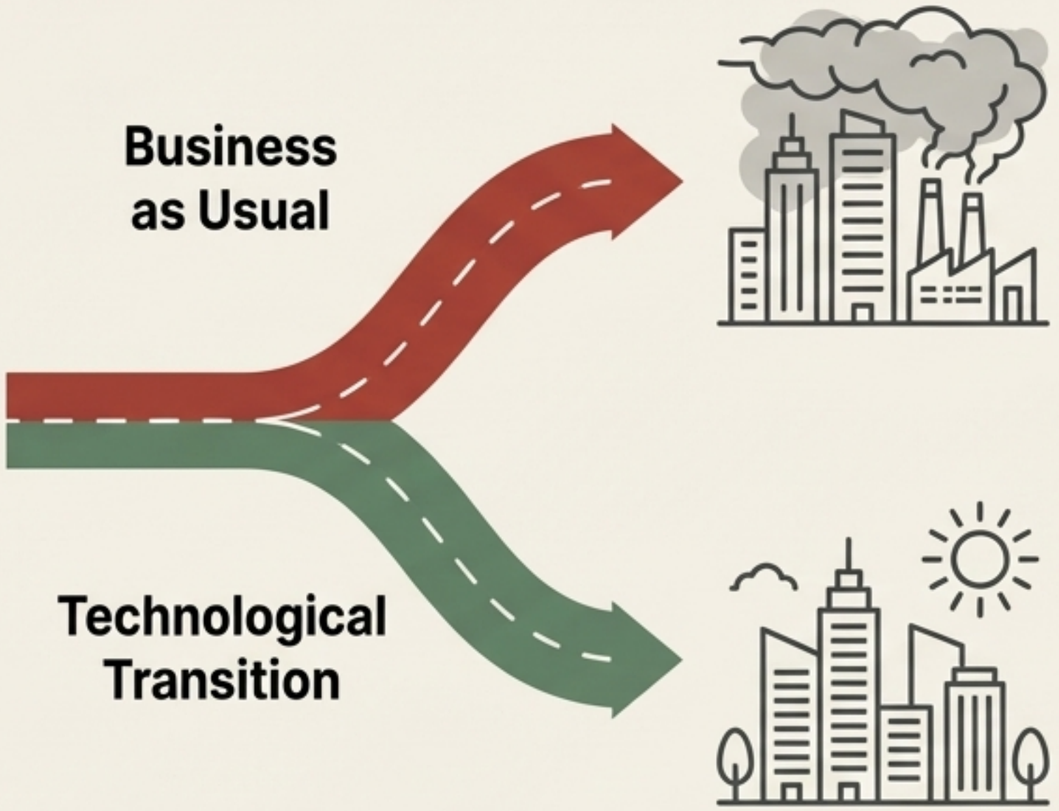
The Solution is Proven

Improved technologies, particularly the Zig-Zag kiln, offer a dramatic and immediate path to lower emissions. It is a practical upgrade, not a hypothetical replacement.

The Prize is Transformative

A full technological transition would slash the industry's climate impact, improve public health, and represents one of the most significant, achievable mitigation opportunities in South Asia.

This scientific evidence provides the foundation for policy that can deliver immediate climate and health benefits.



Key Policy & Industry Actions:

1. **Update Inventories:** Revise national and global emission inventories using these new, accurate emission factors.
2. **Incentivize Conversion:** Create targeted policies and financial incentives to accelerate the transition from BTKs to Zig-Zag kilns and from traditional batch kilns to VSBKs.
3. **Promote Best Practices:** Support further research and training on operational best practices to minimize emissions throughout the entire production season.

Source & Reference

Weyant, C., Athalye, V., Ragavan, S., Rajarathnam, U., Lalchandani, D., Maithel, S., Baum, E., & Bond, T. C. (2014). Emissions from South Asian Brick Production. *Environmental Science & Technology*, *48*(11), 6477–6483. https://doi.org/10.1021/es500186g

Acknowledgments

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