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To Adopt or Not to Adopt That is the Question: An Environmental and Economic Case for Zigzag Kilns

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About the project

Funded by: IGC

Key Counterpart: Environment Protection Department

Impact

The research was disseminated at the CDPR policy talk which was attended by the Punjab Environmental Protection Department as well as private sector actors and brick kiln owners. The outputs were also shared with the new Secretary of the Environmental Protection Department to discuss the challenges to the scale up, which is now being pursued by the Environmental Protection Department in collaboration with the Technical Education and Vocational Training Authority (TEVTA) (government's apex technical trainings organisation).

In brief

- Spread widely across Punjab, BTKs use almost 40 percent of locally extracted coal and are a significant source of greenhouse gas emissions and harmful particulate matter in the province.
- Substituting conventional Bull's Trench Brick Kilns (BTK) for resource-optimizing Induced Draft Zigzag Kilns (ZZK) can reduce emissions by 70%.
- Economic benefits will include lower health and other social costs, as well as production of higher quality bricks, with lower input costs and higher private profits

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The Context

Urbanization and infrastructure development in Pakistan have led to rapid growth of its brick industry. Pakistan is the third largest producer of bricks in South and Southeast Asia after China and India (Skinder et al. 2014). It has an estimated 11,500 brick kilns—with 10,000 located in Punjab—which consume 1.6 million tons of coal to produce 45 billion bricks per year (Techno Green Associates 2012). While other countries in the region have quickly adopted cleaner brick kilns, Pakistan has failed to modernize its conventional kiln technology—the over a century old Bull's Trench Kiln (BTK). The introduction of new kiln technologies such as the Induced Draft Zigzag Kiln (ZZK) presents policymakers an opportunity to improve ambient air quality, mitigate climate change, and in turn reduce social costs.

The Problem

Evidence indicates that emissions in Punjab are increasing at an alarming rate and that levels of pollutants exceed the thresholds prescribed by the World Health Organization (WHO) (Khan et al. 2011). During a menacing smog episode in November 2017, the average concentration of PM_2.5—microscopic air particles that can cause severe health problems when ingested—in Lahore was almost 200 times higher than WHO's safe limit. Exposure to such toxic levels of particulate matter increases the incidence of cancer and can lead to severe cardiovascular and respiratory illnesses such as ischemia (stroke), myocardial infarction (heart attack), asthma, and bronchitis (Kamal et al. 2014). According to WHO estimates, about 135,000 people in Pakistan died in 2015 as a result of exposure to hazardous levels of PM_2.5 (HEI 2017).

Deteriorated air quality also carries serious non-health implications. Visibly poor air quality increases the risk of traffic accidents and encourages people to spend more time indoors, leading to high absenteeism at work and in schools (Sager 2016; Gilliland et al. 2001). Moreover, the exposure of plants and crops to air pollutants causes foliar damage and stunts growth by affecting their ability to photosynthesize (Adrees et al. 2016). The high indirect costs of emissions, in addition to their direct impacts, make it all the more important for authorities in Punjab to reduce emissions and improve air quality in the province.

The Conventional Technology: Bull's Trench Kiln

Spread widely across Punjab, BTKs use almost 40 percent of locally extracted coal and are a significant source of greenhouse gas emissions and harmful particulate matter in the province. At times, kiln operators burn cheap waste materials such as discarded tires, plastics, and garbage as fuel, resulting in the release of toxic byproducts in the surrounding environmental media. (Sanjel et al. 2016). BTKs are also a source of carcinogens, putting kiln workers at high risk of exposure through dermal contact and inhalation (Chen et al. 2017). Moreover, the disposal of kiln ash, which contains toxic heavy metals, can contaminate agricultural land and produce (Mondal et al. 2017).

The New Technology: Induced Draft Zigzag Kiln

ZZK is a cleaner alternative to the conventional BTK. Recent experiences from India and Nepal—where a large number of kiln owners have quickly taken up ZZK technology—suggest that ZZKs generate 70 percent less emissions compared to BTKs (Maithel, Kumar, and Lalchandani 2014). The significantly lower emissions of greenhouse gases and particulate matter improve ambient air quality, leading to better social outcomes such as lower healthcare expenditures, higher crop yields, less material damage, and higher attendance rates at schools and workplaces.

ZZKs also have the potential to generate considerable profit margins if properly operated. Owing to the even and consistent distribution of heat through their chambers and the efficient consumption of coal, ZZKs produce 25 percent more high-quality bricks and use 30 percent less fuel (primarily coal) compared to BTKs (Maithel, Kumar, and Lalchandani 2014). The production of more high-quality bricks and lower input costs translate into higher net private benefits for ZZK owners.

The low capital investment required for the technology shift is another private financial incentive to substitute ZZKs for BTKs. ZZK technology can be integrated into existing BTK infrastructure through a fairly straightforward process: owners must install an electric fan in the chimney, which artificially induces and regulates air draft through the kiln, and stack bricks in a zigzag arrangement within the kiln (Weyant et al. 2014). If investors can recover their startup costs in a reasonably short period of time, converting existing BTKs into ZZKs and setting up new ZZKs would be financially prudent ventures.

The Policy Opportunity

Encouraging kiln owners to adopt ZZKs provides an avenue for Punjab's Environmental Protection Department (EPD) to bring the provincial ambient air quality levels closer to the mandated Provincial Environmental Quality Standards for Ambient Air (PEQs). However, the EPD requires assessments on the environmental and economic differences between ZZKs and BTKs, which would help it develop an informed plan to support ZZK adoption. We fill this niche by

drawing on kiln data and experiences to provide A portfolio of emissions across the two types of kilns and to quantify the discounted (present value) cost savings from investing in ZZKs and the payback period for such investments.

The Study

In our study, we focus on two questions: How clean are ZZKs? What are the economic and social benefits of ZZKs compared to BTKs? To answer the first question, we collected and tested emissions samples from two sites: a newly constructed ZZK in Raiwind, Punjab and a conventional BTK located about 3 kilometers from the ZZK. To address the second question, we drew on data on input and output quantities and prices to conduct a cost-benefit analysis of the two types of kiln technologies.

An enterprising kiln owner recently setup the ZZK in Raiwind after procuring design plans from the International Center for Integrated Mountain Development (ICIMOD) in Nepal. To the best of our knowledge, this is the only currently operational ZZK in Punjab; it provides a benchmark to compare the environmental and economic impacts of conventional kilns in the province.

The Environmental Results

The following are the key results of the environmental assessment of the sample ZZK and BTK:

- For an equal number of bricks produced, the ZZK used 22 percent less coal than the BTK;
- In terms of emissions that deteriorate ambient air quality, the ZZK emitted 42, 38, and 8 times less PM_2.5, sulfur dioxide, and carbon monoxide, respectively, compared to the BTK;
- In terms of greenhouse gases, carbon dioxide emissions of the ZZK were 3 times lower than those of the BTK;
- Substituting BTKs for ZZKs can significantly reduce the environmental impact of the brick industry.

The Economic Results

The following are the key results of the economic assessment—based on a 20-year kiln lifespan and a 10 percent discount rate—of ZZKs and BTKs:

- The present values of private net benefits (revenue from brick sales minus operational and investments costs) of employing ZZKs and BTKs are Rs. 195 million per kiln and Rs. 85 million per kiln, respectively;
- The present values of social net benefits (private net benefits minus the cost of carbon emissions) of employing ZZKs and BTKs are Rs. 171 million per kiln and Rs. 50 million per kiln, respectively;
- However, the figures for social net benefits are upper bounds given the absence of international prices for emissions of gases and pollutants other than carbon dioxide;
- The discounted costs of carbon emissions under IDZKs and BTKs are Rs. 2 per brick and Rs. 3.5 per brick, respectively;
- ZZK owners can recover their initial investment in 1.5 years while it takes BTK owners 2.4 years to recover their initial investment;
- Switching from BTKs to ZZKs can significantly improve social welfare—in monetary terms, social benefits are more than tripled over a 20-year time horizon.

The Steps Forward

The environmental and economic assessments clearly demonstrate the advantages of substituting ZZKs for BTKs. However, the role of the EPD in helping kiln owners make this transition is not clear-cut. We draw on insights from interviews with the managerial staff at our sample ZZK site and from literature on India and Nepal's experiences with ZZKs to list some of the important steps that the EPD must take to facilitate the adoption of ZZKs in Punjab:

- Provide soft loans to prospective investors to help finance the costs of retrofitting BTKs with ZZK technology—approximately Rs 40 million per kiln;
- Ensure consistent electricity supply at ZZK sites to power the electric fans in the chimneys and maintain continuous operations;
- Establish a demonstration site to train ZZK workers and to offer technical assistance on ZZK construction and the brick stacking and baking processes;
- Create a network of ZZK owners in South Asia for knowledge transfer and exchange;
- Organize kiln conventions and support visits of local kiln owners to foreign conventions;
- Engage with ICIMOD, which has had great success with promoting ZZKs in Nepal.