

FINANCIAL AND ECONOMIC ANALYSES

Financial Analysis

1. The financial viability of the Financing Brick Kiln Efficiency Improvement Project is based on the technical and commercial viability of improved zigzag kilns, vertical shaft brick kilns (VSBKs), hybrid Hoffman kiln (HHKs), and tunnel kilns. The financial model uses the medium manufacturing capacity of each brick kiln type as the benchmark to establish clay, coal, labor, and other costs. The results from the financial models, particularly project financial internal rate of return (FIRR) and equity FIRR,¹ are compared with those of the fixed chimney kiln (FCK).

2. **FCK.** The project and equity FIRRs are 23.7% because there is no debt financing. The payback period is 3.8 years. The profitability reflects FCKs' relatively low capital investment at about \$60,000-\$70,000 per unit and low operating cost reflected in the cheap land rental cost of about \$400,000 per year, low labor cost from hiring migrant workers during the 5–6 months of operating season (\$22.0 per 1,000 bricks), and the assumption that there is no financing cost because the initial investment capital is low. The main cost driver is poor energy efficiency as reflected in the coal unit cost at \$22.0 per 1,000 bricks. The project FIRR of 23.7% is higher than the 12.2% weighted average cost of capital (WACC).

3. **Improved Zigzag Kiln.** Because of the similar mechanical designs, FCKs can be upgraded to improved zigzag kilns with an incremental investment. The average upgrade cost, including labor, materials (bricks, sand, and cement), and machinery (blower and coal charging burner), with included technical advice, is about \$42,000 per kiln. Technical expertise and machinery will be imported. The average cost could vary from \$16,000 to \$70,000 per kiln, depending on the level of mechanical automation, and the maximum cost is \$300,000. Compared to FCKs' project FIRR of 23.7%, improved zigzag kilns' project FIRR of 34.0% reflects improved energy efficiency from reduced coal unit consumption cost from \$65,854 (FCK) to \$52,123 (improved zigzag kiln) per 3 million bricks production, with coal consumption efficiency improved from \$22.0 per 1,000 bricks for FCKs to \$17.4 per 1,000 bricks for improved zigzag kilns. Other running costs for improved zigzag kilns—clay, land rental, and labor remain the same as for FCKs.² There is minimum change in the quality of bricks to materially affect the brick price. The payback period is shortened from 3.8 years for FCKs to 3.7 years for improved zigzag kilns. The equity FIRR is 27.5%, and the project FIRR is 34.0%, which is higher than the 12.2% WACC.

4. **VSBK.** VSBKs' project FIRR is 33.6% with a payback period of 6.1 years. Compared to FCKs and improved zigzag kilns, VSBKs have a slightly higher annual production volume from 3 million bricks to 4 million bricks with the similar brick quality and price. Energy efficiency (coal consumption) improves dramatically from \$17.4 per 1,000 bricks for improved zigzag kilns to \$11.0 for VSBKs. The labor cost per 1,000 bricks also reduces from \$22.0 to \$14.3. However, the substantial land development cost, estimated at Tk. 8,000,000 (\$95,000), comparing to Tk. 4,000,000 (\$47,000) for FCKs and improved zigzag kilns over the 10-year project life cycle,³ lowered the otherwise higher overall project and equity FIRRs. Compared to those of improved

¹ Project FIRR disregards the financing cost to reflect the viability of the project as a whole. The equity FIRR includes the deduction of the financing cost to reflect the commercial viability to the brick kiln owners

² The incremental project FIRR for an FCK owner to upgrade to improved zigzag kiln, calculated on the net cash flow from improved coal consumption minus financing cost, is 36.3%, with a payback period of 2.6 years. This means that it is financially viable for the FCK owners to upgrade to improved zigzag kiln.

³ Such a cost is reflected in the Administrative and Selling Costs

zigzag kilns, the running cost of clay and labor for VSBKs remain roughly the same. The equity FIRR is 18.3%, and the project FIRR is 33.6%, which is higher than the 12.2% WACC.

5. **HHK and Tunnel Kiln.** HHKs and tunnel kilns are among the most technologically advanced brick kilns. They have a much higher initial capital investment, about \$2 million–4 million, compared to \$50,000 - \$250,000 for FCKs, improved zigzag kilns, and VSBKs. For HHKs and tunnel kilns, the revenue drivers are (i) the much larger production volume at 15 million bricks for HHKs to 30 million bricks for tunnel kilns, (ii) the higher brick unit price of \$0.8 for HHKs and \$0.9 for tunnel kiln, (iii) the improved energy efficiency (coal cost) of \$11.9 per 1,000 bricks for HHKs and \$11.0 per 1,000 bricks for tunnel kilns, (iv) the low labor cost at \$3.5 per 1,000 bricks for HHKs and \$1.3 per 1,000 bricks for tunnel kilns. They all compare favorably with those of FCKs, improved zigzag kilns, and VSBKs (see Table 1). However, the higher land development cost for HHKs and the higher financing cost for HHKs and tunnel kilns affect the otherwise higher project and equity FIRRs. The equity FIRR for HHKs is 20.6%, and the project FIRR is 37.5%, which is higher than the 12.2% WACC. The equity FIRR for tunnel kilns is 21.3%, and the project FIRR is 35.1%, which is also higher than the 12.2% WACC.

Table 1: Comparison of Main Cost and Revenue Drivers

Item	FCK ^a	Improved Zigzag Kiln ^a	VSBK ^b	HHK ^b	Tunnel Kiln ^b
Brick unit price	\$0.07	\$0.07	\$0.07	\$0.08	\$0.09
Coal cost efficiency per 1,000 bricks	\$22.0	\$17.4	\$11.0	\$11.9	\$11.0
Labor cost efficiency per 1,000 bricks	\$22.0	\$22.0	\$14.3	\$3.5	\$1.3
Annual land cost/1,000 bricks	Tk.1,333.3	Tk.1,333.3	Tk.2,000.0	Tk.1,733.3	Tk.1,200.0
Annual financing cost	\$0	\$7,000	\$40,000	\$300,000	\$600,000

FCK = fixed chimney kiln, HHK = hybrid Hoffman kiln, VSBK = vertical shaft brick kiln.

^a The land cost is for 10 years of project cycle.

^b The land cost is a one-time cost during the first year.

Source: ADB staff estimates

6. Financial model for improved zigzag kilns, VSBKs, HHKs, and tunnel kilns are provided in Table 4–Table 7 at the end of the text.

Economic Analysis

7. The more energy efficient VSBKs, HHKs, and tunnel kilns provide far greater positive externalities to the environment and society in terms of (i) the potential carbon (reduction) credits, (ii) the profit from rice cultivation by returning FCK sites to agricultural use, (iii) the coal savings from more energy efficient kilns (to make the same number of bricks), (iv) the clay savings from expected future development of perforated and hollow bricks, (v) the health benefits from reduced carbon dioxide emissions and fine particulate pollution, and (vi) the improved revenues from the production of higher quality bricks. All input assumptions are based on firsthand market data collection, except the health benefits, which is based on the World Bank calculation.⁴

8. The economic model estimates the total project economic benefits on the basis of the constructions of, from year 1 to year 3 of the project implementation, (i) 40, 60, and 100

⁴ The World Bank. 2011. Introducing Energy-efficient Clean Technologies in the Brick Sector of Bangladesh. Washington, DC.

improved zigzag kilns, (ii) 4, 6, and 10 VSBKs, (iii) 1, 1, and 1 HHKs, and (iv) 0, 1, and 1 tunnel kilns. The basic assumptions include (i) constant price, (ii) a standard conversion factor of 0.9 for Bangladesh and a shadow wage rate of 0.9, (iii) US dollars as the unit of account (based on current exchange rate of Tk. 81.7 = \$1), (iv) FCK's site is about 1 hectare (2.5 acre), and (v) there are about 4,500 FCKs.

Table 2: Project Economic Analysis
(\$ million)

Year	Capital Cost	O&M Cost	Total Cost	Nonincremental			Net Benefits	Net Benefits with Environmental Benefits
				Incremental Benefits	Environmental Benefits	Environmental Benefits		
2012	6.2	0.8	7.0	0.3	6.7	0.0	0.0	0.1
2013	12.0	8.8	20.8	1.8	17.6	0.2	(1.4)	(1.2)
2014	16.5	21.4	37.9	2.4	34.9	0.6	(0.6)	(0.1)
2015	...	39.0	39.0	3.4	35.8	1.0	0.3	1.3
2016	...	39.0	39.0	3.4	36.5	1.0	0.9	1.9
2017	...	39.0	39.0	3.4	37.2	1.0	1.6	2.6
2018	...	39.0	39.0	3.4	37.2	1.0	1.6	2.6
2019	...	39.0	39.0	3.5	37.2	1.0	1.6	2.6
2020	...	39.0	39.0	3.5	37.2	1.0	1.6	2.6
2021	...	39.0	39.0	3.5	37.2	1.0	1.6	2.7
2022	...	39.0	39.0	3.5	37.2	1.0	1.7	2.7
EIRR							38.5%	85.3%

... = not available, () = negative, EIRR = economic internal rate of return, O&M = operation and maintenance.
Source: ADB staff estimates.

9. With the current carbon market condition, if the project could successfully sell all the carbon credits, it is expected that the certified emission reduction (CER)⁵ benefits be significant. Without factoring in the CER benefits, the economic internal rate of return (EIRR) for the entire project is 38.5%. When factoring in the CER benefits, assuming all carbon credits could be sold at the current price, the EIRR is 85.3%.

Table 3: Sensitivity Analysis

Change	ENPV	EIRR	Switching Sensitivity Value		Switching Sensitivity Indicator	
			EIRR	EIRR	ENPV	ENPV
Base Cost	2.92	38.47%				
Capital Cost	+10%	0.24	13.15%	-10.45%	-9.57	-10.89%
Incremental Benefits	-10%	1.36	23.61%	17.81%	5.61	18.73%

ENPV = economic net present value, EIRR = economic internal rate of return.
Source: ADB staff estimates.

⁵ Certified Emission Reductions are a type of emissions unit (or carbon credits) issued by the Clean Development Mechanism Executive Board for emission reductions achieved by CDM projects and verified by a designated operational entity under the rules of the Kyoto Protocol.

10. The two sensitivity analyses stress-test the EIRR model by increasing the capital cost by 10% (Table 3) and decreasing the incremental benefits by 10% (Table 3).⁶ These two scenarios are likely because the underlying factors (capital cost and brick revenue from more energy efficient operations) are easily affected by the project implementation and market conditions. In the former case, the increase of capital cost (variable) by 10% will result in a change in the EIRR and economic net present value (ENPV) by 95.7% and 91.8% respectively. For the same token, a decline of 10.5% and 10.9% in capital cost will cause the respective EIRR and ENPV to zero. In the latter case, the decrease of incremental benefits (variable) by 10% will result in a change of EIRR and ENPV by 56.1% in EIRR and 53.4% of ENPV. For the same token, a decline of 17.8% and 18.7% in incremental benefits will cause the respective EIRR and ENPV to zero.

⁶ Incremental benefits include (i) the cost of rice production gains from returning the FCK sites for agriculture use and (ii) the additional brick revenue from more energy efficient operations.

Table 5: Financial Analysis (Vertical Shaft Brick Kiln)

	(\$)										
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Capital Investment Cost	(226,438)										
Production (Number of Bricks)	2,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000
Price per Brick	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071
Total Revenue	142,815	285,630	285,630	285,630	285,630	285,630	285,630	285,630	285,630	285,630	285,630
Clay Cost	19,584	39,168	39,168	39,168	39,168	39,168	39,168	39,168	39,168	39,168	39,168
Coal Cost	22,032	44,064	44,064	44,064	44,064	44,064	44,064	44,064	44,064	44,064	44,064
Total Raw Material Cost	41,616	83,231	83,231	83,231	83,231	83,231	83,231	83,231	83,231	83,231	83,231
Labor Cost	28,641	57,283	57,283	57,283	57,283	57,283	57,283	57,283	57,283	57,283	57,283
Administrative and Selling Cost	24,480	48,960	48,960	48,960	48,960	48,960	48,960	48,960	48,960	48,960	48,960
Total Operating Cost	94,737	189,474	189,474	189,474	189,474	189,474	189,474	189,474	189,474	189,474	189,474
Operating Profit	(178,360)	96,157	96,157	96,157	96,157	96,157	96,157	96,157	96,157	96,157	96,157
Financing Cost	...	47,829	44,342	40,855	37,368	33,881					
Tax	...	30,011	31,318	32,626	33,934	35,241	36,059	36,059	36,059	36,059	36,059
Add: Salvage Value											156,671
Cash Flow	(178,360)	18,317	20,496	22,675	24,855	27,034	60,098	60,098	60,098	60,098	216,769
Cash Flow Without Debt Cost	(178,360)	66,146	64,838	63,531	62,223	60,915	60,098	60,098	60,098	60,098	60,098
Equity FIRR											18.25%
Project FIRR											33.63%
Payback Period											6.08
WACC											12.20%

... = not available, () = negative, FIRR = financial internal rate of return, WACC = weighted average cost of capital.

Source: ADB staff estimates.

Table 6: Financial Analysis (Hybrid Hoffman Kiln)

	(\$)										
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Capital Investment Cost	(1,682,987)										
Production (Number of Bricks)	7,500,000	15,000,000	15,000,000	15,000,000	15,000,000	15,000,000	15,000,000	15,000,000	15,000,000	15,000,000	15,000,000
Price per Brick	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084
Total Revenue	631,579	1,263,158	1,263,158	1,263,158	1,263,158	1,263,158	1,263,158	1,263,158	1,263,158	1,263,158	1,263,158
Clay Cost	73,439	146,879	146,879	146,879	146,879	146,879	146,879	146,879	146,879	146,879	146,879
Coal Cost	89,504	179,009	179,009	179,009	179,009	179,009	179,009	179,009	179,009	179,009	179,009
Total Raw Material Cost	162,944	325,887	325,887	325,887	325,887	325,887	325,887	325,887	325,887	325,887	325,887
Labor Cost	26,438	52,876	52,876	52,876	52,876	52,876	52,876	52,876	52,876	52,876	52,876
Administrative and Selling Cost	56,763	113,525	113,525	113,525	113,525	113,525	113,525	113,525	113,525	113,525	113,525
Total Operating Cost	246,144	492,289	492,289	492,289	492,289	492,289	492,289	492,289	492,289	492,289	492,289
Operating Profit	(1,297,552)	770,869	770,869	770,869	770,869	770,869	770,869	770,869	770,869	770,869	770,869
Financing Cost	...	355,489	329,571	303,653	277,735	251,817					
Tax	...	244,124	253,844	263,563	273,282	283,001	289,076	289,076	289,076	289,076	289,076
Add: Salvage Value											1,011,506
Cash Flow	(1,297,552)	171,256	187,455	203,653	219,852	236,051	481,793	481,793	481,793	481,793	1,493,299
Cash Flow Without Debt Cost	(1,297,552)	526,745	517,025	507,306	497,587	487,868	481,793	481,793	481,793	481,793	481,793
Equity FIRR											20.58%
Project FIRR											37.53%
Payback Period											5.58
WACC											12.20%

... = not available, () = negative, FIRR = financial internal rate of return, WACC = weighted average cost of capital.

Source: ADB staff estimates.

Table 7: Financial Analysis (Tunnel Kiln)

	(\$)										
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Capital Investment Cost	(3,550,796)										
Production (Number of Bricks)	3,750,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000
Price per Brick	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091
Total Revenue	340,346	2,722,766	2,722,766	2,722,766	2,722,766	2,722,766	2,722,766	2,722,766	2,722,766	2,722,766	2,722,766
Clay Cost	36,720	293,758	293,758	293,758	293,758	293,758	293,758	293,758	293,758	293,758	293,758
Coal Cost	41,310	330,477	330,477	330,477	330,477	330,477	330,477	330,477	330,477	330,477	330,477
Total Raw Material Cost	78,029	624,235	624,235	624,235	624,235	624,235	624,235	624,235	624,235	624,235	624,235
Labor Cost	...	39,657	39,657	39,657	39,657	39,657	39,657	39,657	39,657	39,657	39,657
Administrative and Selling Cost	...	201,958	201,958	201,958	201,958	201,958	201,958	201,958	201,958	201,958	201,958
Total Operating Cost	78,029	865,851	865,851	865,851	865,851	865,851	865,851	865,851	865,851	865,851	865,851
Operating Profit	(3,288,479)	1,856,916	1,856,916	1,856,916	1,856,916	1,856,916	1,856,916	1,856,916	1,856,916	1,856,916	1,856,916
Financing Cost	...	750,017	695,335	640,652	585,970	531,288					
Tax	...	601,504	622,010	642,515	663,021	683,527	696,343	696,343	696,343	696,343	696,343
Add: Salvage Value											2,622,277
Cash Flow	(3,288,479)	505,395	539,571	573,748	607,924	642,101	1,160,572	1,160,572	1,160,572	1,160,572	3,782,849
Cash Flow Without Debt Cost	(3,288,479)	1,255,412	1,234,906	1,214,400	1,193,894	1,173,388	1,160,572	1,160,572	1,160,572	1,160,572	1,160,572
Equity FIRR											21.34%
Project FIRR											35.10%
Payback Period											5.36
WACC											12.20%

... = not available, () = negative, FIRR = financial internal rate of return, WACC = weighted average cost of capital.

Source: ADB staff estimates.