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BAGASSE UTILISATION AND POWER GENERATION EFFICIENCY IN THE SUGAR INDUSTRY: AN ECONOMIC ANALYSIS OF NSL FACTORY, MANDYA DISTRICT

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Abstract: Bagasse, the fibrous residue generated after crushing sugarcane, has evolved from a low-value by-product into a valuable feedstock for cogeneration in the Indian sugar industry, enabling factories to meet internal energy needs and export surplus power to the grid. This study presents a decade-long (2009-10 to 2018-19) economic analysis of bagasse utilisation and power generation efficiency in the NSL sugar factory, Mandya district, Karnataka, based on secondary data on bagasse consumption, power generation, capacity utilisation, power allocation, and revenue. Results show that while bagasse consumption remained nearly stagnant (CAGR -0.12%), power generation declined sharply (-8.61% CAGR), and the bagasse-to-power ratio rose from 1.28 to 2.84 tonnes/MW (CAGR +9.29%), indicating deteriorating conversion efficiency rather than feedstock shortage. Capacity utilisation collapsed from over 96 per cent in 2009-11 to 41.21 per cent in 2017-18. Comparative analysis of power generation versus direct bagasse sale revealed that cogeneration was substantially more profitable in the early years (profit margins up to 204.72%), but this advantage eroded sharply (CAGR -25.34%) due to rising bagasse prices and falling generation efficiency, narrowing to just 6.56-14.75 per cent by 2017-19. The study concludes that sustaining the economic viability of bagasse cogeneration requires improved plant efficiency and capacity utilisation to withstand rising feedstock costs and shrinking exportable surplus.

Index Terms - Bagasse, Cogeneration, Capacity Utilisation, Power Generation Efficiency, Sugar Industry, Revenue Analysis,

I. INTRODUCTION

Sugarcane occupies a pivotal position in India's agricultural economy, and Karnataka ranks among the leading sugarcane-producing states in the country, with Mandya district historically recognised as one of its traditional sugar belts. Beyond its role as a source of sugar, the sugar industry generates substantial quantities of bagasse — the fibrous residue left after crushing cane for juice extraction — which constitutes nearly 30 per cent of the cane crushed. For decades, bagasse was treated merely as a low-value by-product, either sold in the open market for use as fuel in boilers, paper and board manufacturing, or disposed of as waste. However, with escalating energy demand, rising fossil fuel prices, and growing policy emphasis on renewable and biomass-based energy sources, bagasse has increasingly been recognised as a valuable feedstock for cogeneration — the simultaneous production of steam and electricity within the sugar factory premises.

Bagasse-based cogeneration offers a dual advantage: it enables sugar factories to meet their own substantial internal energy requirements for milling, boiling, and processing operations, while any surplus power generated can be exported to the state grid, creating an additional and often significant revenue stream. This has transformed many sugar factories from being purely sugar-manufacturing units into partial energy-generating enterprises, with implications for their overall financial viability, especially during periods when sugar prices are depressed or cane availability is constrained. Government policies promoting renewable purchase obligations and preferential tariffs for biomass power have further incentivised factories to invest in cogeneration infrastructure.

However, the technical and economic performance of bagasse cogeneration is not uniform across factories or across time. Efficiency of conversion, capacity utilisation of the cogeneration plant, the balance between internal consumption and grid export, and the relative profitability of generating power versus simply selling surplus bagasse in the market are all influenced by factors such as plant age, maintenance practices, cane crushing volumes, working days, and prevailing market prices for both bagasse and power. Despite the growing policy and commercial significance of this sector, there is a paucity of factory-level, longitudinal economic studies that examine these dimensions jointly over an extended period, particularly in the Karnataka context. Most existing literature tends to focus either on the engineering aspects of cogeneration technology or on aggregate, state- or national-level energy statistics, offering limited insight into how an individual factory's bagasse utilisation, power generation efficiency, and revenue performance evolve over time in response to changing operational and market conditions.

Against this backdrop, the present study undertakes a detailed, decade-long (2009-10 to 2018-19) economic analysis of bagasse utilisation and power generation in the NSL sugar factory located in Mandya district, Karnataka. By examining trends in bagasse consumption, power generation efficiency, capacity utilisation, the internal-versus-export allocation of power, and the comparative profitability of power generation vis-à-vis direct bagasse sale, the study seeks to provide empirical, factory-level evidence that can inform both managerial decision-making within the sugar industry and broader policy discourse on promoting efficient biomass-based cogeneration in India's sugar sector.

II. OBJECTIVES

1. To examine the trend in quantity of bagasse utilised, power generated, and capacity utilisation of the cogeneration plant in NSL sugar factory, Mandya district, during 2009-10 to 2018-19.
2. To analyse the pattern of utilisation of power generated by the factory, in terms of internal consumption and power exported to the grid.
3. To evaluate the comparative economics of power generation from bagasse through direct sale of bagasse, and to assess the revenue realised from the sale of surplus power.

III. METHODOLOGY

The present study was conducted in NSL sugar factory located in Mandya district, Karnataka, purposively selected owing to its long-standing bagasse-based cogeneration facility and the availability of consistent time-series records. The study is based entirely on secondary data pertaining to bagasse consumption, power generation, capacity utilisation, internal power consumption, power exported to the grid, ex-mill prices of bagasse and power, and associated revenue and cost figures, compiled for a ten-year period from 2009-10 to 2018-19 through field visits and factory records. Simple tabular analysis was employed to present year-wise trends in physical and financial indicators. Descriptive statistics — mean, standard deviation (SD), and coefficient of variation (CV) — were computed to assess the level and variability of each indicator over the study period. The compound annual growth rate (CAGR) was estimated using the exponential growth function to capture the average annual rate of change in bagasse utilisation, power generation, capacity utilisation, internal-versus-exported power shares, and revenue/profitability indicators. Profit margins were derived by comparing net revenue from power generation against the revenue forgone from direct bagasse sale, enabling an assessment of the relative economic advantage of cogeneration over the study period.

IV. RESULTS AND DISCUSSION

4.1. Bagasse Utilisation and Power Generation Efficiency

The temporal trends in bagasse consumption and power generation in the NSL factory over the study period reveal a distinct pattern of expansion followed by contraction. The quantity of bagasse utilised rose from 2,14,762.47 tonnes in 2009-10 to a peak of 3,16,238.73 tonnes in 2010-11, before declining sharply to a low of 1,03,518.56 tonnes in 2016-17, and recovering only marginally to 2,12,445.99 tonnes by 2018-19. Correspondingly, total power generation followed a similar trajectory, peaking at 1,73,092 MW in 2010-11 and falling to as low as 56,571 MW in 2017-18. Over the ten-year period, bagasse consumption remained virtually stagnant, with a compound annual growth rate (CAGR) of only -0.12 per cent, whereas power generation registered a steep decline of -8.61 per cent per annum. This divergence between an almost flat bagasse-use trend and a sharply declining power output is the most striking finding of Table 1, and it points to a progressive deterioration in the technical efficiency of bagasse-based cogeneration rather than a shortage of feedstock.This inference is reinforced by the bagasse-to-power ratio, which rose consistently from 1.28 tonnes of bagasse per MW in 2009-10 to 2.84 tonnes per MW in 2018-19, registering a positive CAGR of 9.29 per cent — the highest growth rate among all indicators in the table.

Table 1: Details of Bagasse Utilised and Power Generated in NSL factory 2009-10 to 2018-19

Year	Quantity of Bagasse Used (Tonne)	Total MW of Power Generated	Tonne of Bagasse per MW of Power	Number of Working Days	MW of Power generated Per Day *	Capacity Utilisation (%)
	1	2	3=1x2	4	5=2/4	6=5/624
2009-10	2,14,762.47	1,68,222.00	1.28	280.00	600.79	96.28
2010-11	3,16,238.73	1,73,092.00	1.83	280.00	618.19	99.07
2011-12	2,71,951.24	1,41,117.00	1.93	260.00	542.76	86.98
2012-13	2,79,447.06	1,36,436.00	2.05	260.00	524.75	84.10
2013-14	2,02,884.81	1,38,090.00	1.47	240.00	575.38	92.21
2014-15	3,00,270.90	1,71,767.00	1.75	280.00	613.45	98.31
2015-16	2,90,765.44	1,57,131.00	1.85	280.00	561.18	89.93
2016-17	1,03,518.56	88,112.00	1.17	200.00	440.56	70.60
2017-18	1,44,292.72	56,571.00	2.55	220.00	257.14	41.21
2018-19	2,12,445.99	74,811.00	2.84	240.00	311.71	49.95
Total	**23,36,577.93**	**13,05,349.00**	**18.71**	**2,540.00**	**5,045.91**	**808.64**
Mean	**2,33,657.79**	**1,30,534.90**	**1.87**	**254.00**	**504.59**	**80.86**
S D	**70,519.92**	**42,450.31**	**0.52**	**28.36**	**127.64**	**20.45**
C V	**30.18**	**32.52**	**27.89**	**11.17**	**25.29**	**25.29**
CAGR	**-0.12**	**-8.61**	**9.29**	**-1.70**	**-7.03**	**-7.03**

In effect, nearly twice as much bagasse was required to generate a unit of power towards the end of the study period as was required at the beginning, indicating ageing boiler and turbine infrastructure, incomplete combustion, or inadequate maintenance and modernisation of the cogeneration plant. The number of crushing/working days also fell from 280 days in the early years to 200-240 days in the latter years (CAGR -1.70%), which, combined with the efficiency loss, translated into a marked fall in power generated per day, from a mean of over 600 MW/day in 2009-11 to as low as 257.14 MW/day in 2017-18 (overall CAGR -7.03%).

Capacity utilisation, arguably the single most policy-relevant indicator in this table, mirrors this decline almost exactly: it remained above 96 per cent during 2009-11, but collapsed to 41.21 per cent in 2017-18 before a modest recovery to 49.95 per cent in 2018-19, with an overall CAGR of -7.03 per cent and a coefficient of variation (CV) of 25.29 per cent — the highest variability observed among the physical performance indicators. Such a steep and sustained fall in capacity utilisation, occurring over just five to six years, is unlikely to be explained by feedstock availability alone (since bagasse quantity was near-stagnant) and instead suggests operational constraints such as plant breakdowns, delayed repowering, grid off-take restrictions, or deliberate curtailment of generation. From a policy and managerial standpoint, these results underline that investments in retrofitting or repowering the cogeneration unit and improving preventive maintenance schedules could be critical to restoring the bagasse-to-power conversion efficiency and capacity utilisation levels observed in the initial years of the study period.

4.2. Pattern of Power Utilisation: Internal Consumption versus Grid Export:

Table 2 disaggregates the total power generated (which mirrors the figures in Table 1) into power consumed internally by the factory and power exported to the grid, and the results reveal a clear structural shift in this allocation over the decade. In 2009-10, internal consumption accounted for only 21.03 per cent (35,374.80 MW) of total generation, with the remaining 78.97 per cent (1,32,847.20 MW) exported. By 2018-19, this pattern had reversed considerably, with the internal share rising to 42.84 per cent and, in the intervening year 2017-18, reaching a peak of 46.93 per cent — nearly half of all power generated that year was consumed captively rather than sold to the grid.

TABLE 2: UTILISATION OF POWER IN THE NSL FACTORY 2009-10 TO 2018-19

Year	Total MW of Power Generated	Internal Consumption		Exported to Power Grid	
		Quantity (MW)	% share	Quantity (MW)	% Share
	1	2	3=(2/1)100	4	5=(4/1)100
2009-10	1,68,222.00	35,374.80	21.03	1,32,847.20	78.97
2010-11	1,73,092.00	42,323.80	24.45	1,30,768.20	75.55
2011-12	1,41,117.00	43,537.20	30.85	97,579.80	69.15
2012-13	1,36,436.00	48,376.40	35.46	88,059.60	64.54
2013-14	1,38,090.00	37,389.00	27.08	1,00,701.00	72.92
2014-15	1,71,767.00	45,250.40	26.34	1,26,516.60	73.66
2015-16	1,57,131.00	49,527.00	31.52	1,07,604.00	68.48
2016-17	88,112.00	28,398.80	32.23	59,713.20	67.77
2017-18	56,571.00	26,550.60	46.93	30,020.40	53.07
2018-19	74,811.00	32,048.40	42.84	42,762.60	57.16
Total	**13,05,349.00**	**3,88,776.40**	**318.73**	**9,16,572.60**	**681.27**
Mean	**1,30,534.90**	**38,877.64**	**31.87**	**91,657.26**	**68.13**
S D	**42,450.31**	**8,169.87**	**8.08**	**36,569.22**	**8.08**
C V	**32.52**	**21.01**	**25.35**	**39.90**	**11.86**
CAGR	**-8.61**	**-1.09**	**8.23**	**-11.83**	**-3.53**

Source: Compiled from the data collected from the sugar factory during field visit

This shift becomes even more evident when growth rates are compared. While total power generation declined steeply at -8.61 per cent per annum, the quantity used for internal consumption declined only marginally, at -1.09 per cent per annum, and its percentage share in total generation actually grew at 8.23 per cent per annum. In sharp contrast, the quantity of power exported to the grid fell at -11.83 per cent per annum — faster than the overall decline in generation — and its share of the total fell at -3.53 per cent per annum. The mean share of internal consumption over the study period was 31.87 per cent as against a mean export share of 68.13 per cent, but the trend line makes clear that this balance was moving steadily in favour of internal use.

These results suggest that as overall generation capacity and efficiency declined (as shown in Table 1), the factory management prioritised meeting its own captive power requirements — for milling, boiling, and other in-house operations — over supplying the surplus to the grid. This is an economically rational short-run response, since maintaining uninterrupted internal operations is essential to sustaining core sugar production, even at the cost of forgoing export revenue. However, the consequence, examined further in Table 4, is a disproportionately sharp erosion of the exportable surplus and the associated grid-sale revenue.

The relatively higher CV of exported power (39.90%) compared with internal consumption (21.01%) further confirms that grid export was the more volatile and vulnerable component of the factory's power-utilisation portfolio, making it the primary channel through which declining generation efficiency was ultimately transmitted into revenue losses for the firm.

4.3. Comparative Revenue from Direct Bagasse Sale versus Power Generation (Table 3)

TABLE 3: REVENUE FROM THE DIRECT SELLING AND UTILISATION OF BAGASSE IN THE NSL SUGAR FACTORY DURING 2009-10 TO 2018-19

Year	If Bagasse Sold Directly in market (Before Utilisation)			If all the Generated Power is sold (After Utilisation of Bagasse)			
	Surplus Bagasse Saved * (tonne)	Ex-mill Price per Tonne of Bagasse (Rs.)	Total Revenue (Lakhs)	Quantity of Power Generated (MW)	Total Net Revenue (Lakhs)	Total Profit/loss (Lakhs)	Profit/loss Margin (%)
	1	2	3 =(1x2)	4	5	6=(5-3)	7=(6/3)100
2009-10	69,006.15	800	552.05	168222	1,682.22	1,130.17	204.72
2010-11	1,01,142.45	600	606.85	173092	1,834.78	1,227.92	202.34
2011-12	86,947.11	800	695.58	141117	1,580.51	884.93	127.22
2012-13	89,950.77	600	539.70	136436	1,459.87	920.16	170.49
2013-14	66,278.16	950	629.64	138090	1,270.43	640.79	101.77
2014-15	97,878.96	1200	1174.55	171767	3,297.93	2,123.38	180.78
2015-16	87,550.65	1400	1225.71	157131	2,639.80	1,414.09	115.37
2016-17	34,277.67	1800	617.00	88112	1,453.85	836.85	135.63
2017-18	47,447.37	1600	759.16	56571	808.97	49.81	6.56
2018-19	67,729.86	1800	1219.14	74811	1,398.97	179.83	14.75
Total	**7,48,209.15**	**11,550.00**	**8,019.38**	**13,05,349**	**17,427.31**	**9,407.93**	**1,259.65**
Mean	**74,820.92**	**1,155.00**	**801.94**	**1,30,534**	**1,742.73**	**940.79**	**125.96**
S D	**21,890.23**	**471.67**	**286.51**	**42,450.31**	**717.90**	**597.97**	**70.27**
C V	**29.26**	**40.84**	**35.73**	**32.52**	**41.19**	**63.56**	**55.79**
CAGR	**-0.21**	**9.43**	**9.20**	**-8.61**	**-2.03**	**-18.47**	**-25.34**

Source: Compiled from the data collected from the sugar factory during field visit

Table 3 evaluates whether converting bagasse into power was economically superior to selling the surplus bagasse directly in the open market, and the results show that, for most of the study period, value addition through power generation was substantially more remunerative. In the initial years (2009-10 to 2015-16), the profit margin of power generation over direct bagasse sale ranged from 101.77 per cent to as high as 204.72 per cent, indicating that net revenue from power sale was often two to three times greater than the revenue that could have been earned by selling the equivalent bagasse directly at the prevailing ex-mill price (which itself rose steadily from Rs. 600 to Rs. 950 per tonne during this sub-period).

However, this advantage narrowed sharply in the final three years of the study. The profit margin fell to 135.63 per cent in 2016-17, and then collapsed to just 6.56 per cent in 2017-18 and 14.75 per cent in 2018-19 — years that, notably, coincide with the lowest capacity utilisation and power output recorded in Table 1. Over the full decade, the profit margin exhibited a negative CAGR of -25.34 per cent, the steepest decline of any indicator examined across the four tables, signalling a rapid and consistent erosion of the economic case for power generation relative to direct bagasse sale. This erosion was driven by two simultaneous forces: the ex-mill price of bagasse rose consistently, from Rs. 600-800 per tonne in the early years to Rs. 1,600-1,800 per tonne by 2016-19 (raising the opportunity cost of using bagasse for power), while the quantity and efficiency of power generated from that bagasse were falling (as established in Table 1).

The profit-per-MW figures corroborate this pattern, falling from a peak of Rs. 1,236.20 in 2014-15 to just Rs. 88.04 and Rs. 240.38 in 2017-18 and 2018-19 respectively. Taken together, these results indicate that the comparative advantage of bagasse-based cogeneration over direct bagasse sale is not fixed but is highly sensitive to prevailing bagasse market prices and the technical efficiency of the generation process. The findings imply that, in years of declining generation efficiency and buoyant bagasse prices, factory management would need to critically reassess the allocation of bagasse between cogeneration and direct sale, since the historically wide profitability gap favouring power generation had nearly disappeared by the end of the study period.

The utilization bagasse for the cogeneration of electricity in NSL sugar factory offers three kinds of benefits. One was it makes NSL factory, an energy self-sufficient sugar industry by avoiding the dependency on the KPTCL. Another benefit it offers was that large amount of profit can be earned by surplus power generation that makes sugar industry reduce the loss incurred by sugar production. Yet another benefit was that it reduces burden of environmental pollution caused by bagasse if left unused for cogeneration. In this regard, apart from the economic point of view of sugar industry, utilization of bagasse for power production as renewable energy would reduce the burden of dependency of the country on the conventional production of power using fossil fuel.

It is very clear from the **fig 1** that, the revenue from power after the utilisation of bagasse was higher than the revenue if bagasse sold directly without utilisation through out the period of 10 years from 2009-10 to 2018-19. The revenue from power was highest in the year 2014-15 and lowest in the year 2017-18.

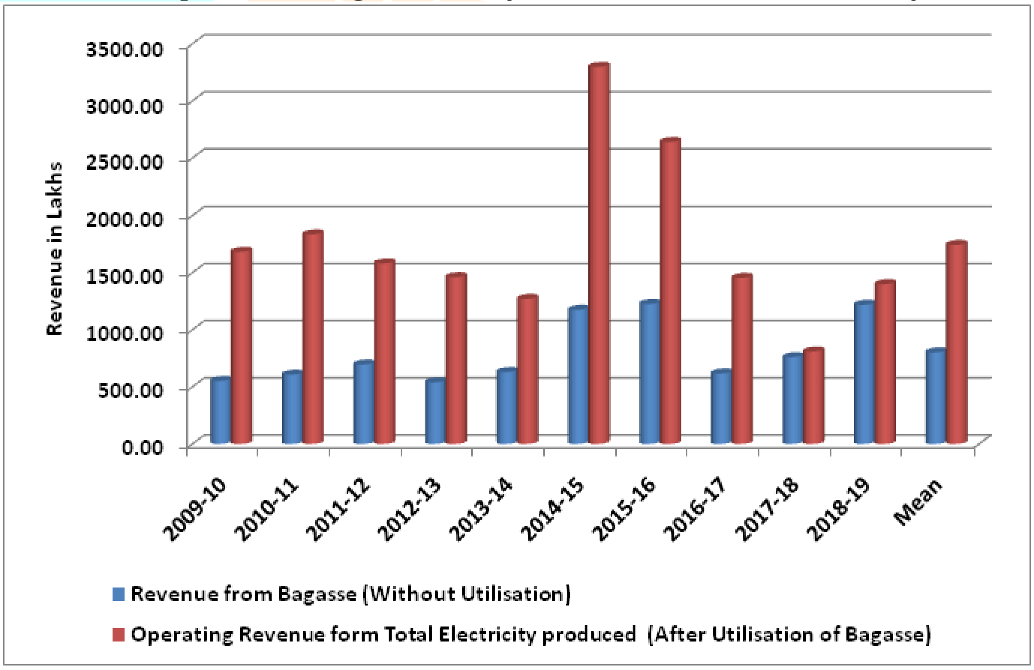

Fig 1: Comparison between Revenue from Bagasse v/s Revenue from Power in NSL Facotry (2019-10 to 2018-19)

4.4. Revenue from Sale of Surplus Power to the Grid:

Table 4 provides a more detailed financial account of the revenue realised specifically from the sale of surplus power to the grid, and the results reveal a widening gap between the price received per unit of power and the profitability of the export operation.

TABLE 4: DETAILS OF REVENUE FROM THE SALE OF SURPLUS POWER IN NSL FACTORY 2009-10 TO 2018-19

Year	Surplus MW of Power Sold	Ex-mill Price per MW of Power (Rs)	Gross Revenue from Sale of Power (Lakhs)	Total Conversion Cost (Lakhs)	Total Revenue * (Lakh)
	1	2	3=2x1	4	5=(3-4)
2009-10	1,32,847.20	2,800.00	3,719.72	3,028.00	691.73
2010-11	1,30,768.20	2,860.00	3,739.97	3,115.66	624.31
2011-12	97,579.80	2,920.00	2,849.33	2,540.11	309.22
2012-13	88,059.60	2,970.00	2,615.37	2,592.28	23.09
2013-14	1,00,701.00	3,020.00	3,041.17	2,899.89	141.28
2014-15	1,26,516.60	4,120.00	5,212.48	3,778.87	1,433.61
2015-16	1,07,604.00	4,280.00	4,605.45	4,085.41	520.05
2016-17	59,713.20	4,450.00	2,657.24	2,467.14	190.10
2017-18	30,020.40	4,630.00	1,389.94	1,810.27	-420.33
2018-19	42,762.60	4,870.00	2,082.54	2,244.33	-161.79
Total	**9,16,572.60**	**36,920.00**	**31,913.22**	**28,561.95**	**3,351.27**
Mean	**91,657.26**	**3,692.00**	**3,191.32**	**2,856.20**	**335.13**
S D	**36,569.22**	**845.10**	**1,149.68**	**687.21**	**519.18**
C V	**39.90**	**22.89**	**36.03**	**24.06**	**154.92**
CAGR	**-11.83**	**6.34**	**-6.24**	**-3.27**	**-185.09**

Source: Compiled from the data collected from the sugar factory during field visit

The ex-mill price of power rose almost every year, from Rs. 2,800 per MW in 2009-10 to Rs. 4,870 per MW in 2018-19, registering a positive CAGR of 6.34 per cent — indicating a generally favourable and appreciating market for power sales throughout the study period. Despite this rising price, gross revenue from power sale did not follow a similarly consistent upward path; it peaked at Rs. 5,212.48 lakhs in 2014-15 (a year of both relatively high surplus volume and a sharp price increase to Rs. 4,120 per MW) and then declined in most subsequent years, falling to Rs. 1,389.94 lakhs in 2017-18, its lowest point in the series.

This decoupling of rising unit price from falling revenue is explained by the steep fall in the surplus quantity of power sold, which declined at a CAGR of -11.83 per cent — consistent with the findings of Tables 1 and 2, where both overall generation and the exportable share of that generation were shown to be shrinking. In other words, a favourable price trend was progressively overwhelmed by a shrinking volume base. Total conversion costs, meanwhile, rose from Rs. 3,028.00 lakhs in 2009-10 to a peak of Rs. 4,085.41 lakhs in 2015-16, before falling in the final years as the volume of power processed declined; overall, conversion cost exhibited a marginal negative CAGR of -3.27 per cent, but this masks considerable year-to-year volatility (CV of 24.06%).

The net outcome of these opposing forces was that net revenue from power sale, while positive throughout 2009-10 to 2016-17 (ranging from Rs. 23.09 lakhs in 2012-13 to a high of Rs. 1,433.61 lakhs in 2014-15), turned negative in the final two years of the study, at -Rs. 420.33 lakhs in 2017-18 and -Rs. 161.79 lakhs in 2018-19. This produced an extreme and somewhat statistically distorted CAGR of -185.09 per cent for net revenue, reflecting the sign reversal from profit to loss rather than a simple proportional decline. Substantively, these results demonstrate that the factory's power-export operation moved from a consistently profitable enterprise to a loss-making one precisely in the years when generation efficiency and capacity utilisation (Table 1) were at their weakest and internal consumption's share (Table 2) was at its highest. This convergence of evidence across all four tables suggests that the financial viability of grid power export from bagasse cogeneration in the NSL factory is fundamentally contingent on maintaining high plant efficiency and capacity utilisation; once these fall below a critical threshold, rising conversion costs and a shrinking exportable surplus can outweigh even a favourable and rising market price for power, turning the export operation loss-making despite the underlying strength of demand.

V. CONCLUSION:

The decade-long analysis of NSL sugar factory reveals a sugar-cum-cogeneration enterprise whose power-generation performance deteriorated substantially even as bagasse availability remained largely stable. The near-stagnant bagasse consumption alongside a steep decline in power output and capacity utilisation points unambiguously to a technical efficiency problem rather than a feedstock constraint, most plausibly linked to ageing cogeneration infrastructure and inadequate maintenance or repowering. This inefficiency cascaded through the entire value chain: it shrank the exportable power surplus faster than internal consumption, eroded the historically wide profitability advantage of power generation over direct bagasse sale, and ultimately pushed the factory's power-export operation into loss in the final two years of the study, despite a consistently rising market price for power.

These findings carry clear policy implications. First, there is an urgent need for targeted financial and technical support — through subsidised loans, capital subsidies, or accelerated depreciation schemes — to enable sugar factories to retrofit or repower ageing cogeneration plants, since efficiency losses of the magnitude observed here can neutralise even favourable price trends in the power market. Second, given the observed shift toward greater internal consumption as generation declined, policies should encourage a minimum threshold of capacity utilisation, potentially linked to eligibility for preferential power-purchase tariffs, so that factories are incentivised to maintain plant performance rather than merely meet captive needs. Third, since the relative profitability of power generation vis-à-vis direct bagasse sale is highly sensitive to bagasse market prices, mechanisms for periodic review and rationalisation of power tariffs are necessary to preserve the economic incentive for cogeneration. Finally, given the significance of this single-factory case, similar longitudinal, factory-level assessments across other sugar mills in Karnataka and India are recommended to validate these findings and to design region-specific interventions that safeguard the long-term viability of bagasse-based cogeneration as a renewable energy source.

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