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Komenda Sugar Factory and Estate:

A Case-Study in Technology Selection and Performance.

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This paper has been written with sympathy for the situation of those in positions of responsibility who have been asked to maintain operations in virtually impossible conditions. The uniqueness of the project, however, makes it particularly suitable for a study of such agro-industrial projects, and of the inter-relationship between the choice of technology and project performance.

Responsibility for remaining errors of omission, interpretation or of fact remains with the author.

KOMENDA SUGAR FACTORY AND ESTATE

A CASE-STUDY IN TECHNOLOGY SELECTION AND PERFORMANCE

This paper consists of an Introduction, a Review of Project Performance, a discussion of Technical Alternatives, a presentation of an Estimate of Economic Performance, an outline of the Scope for Rehabilitation, and a summary of Conclusions. In addition, there are three Appendices consisting a Flow Chart of the Factory Processes, the Technical Specification of the Factory as of 1978, and an outline of Developments between 1979/80 and 1981/82.

I INTRODUCTION

Considerable controversy has surrounded the two large scale sugar factories in Ghana, at Komenda and Asutsuare, relating particularly to their effective failure both technically and economically. This case study will concentrate on the Komenda factory and estate, and will attempt to distinguish between elements of the technological characteristics of the project which might have led to some of the problems, and a range of other factors which have affected project performance.

Comments on both Komenda and Asutsuare projects have been made in studies of the Ghana economy. Ann Seidman bases her remarks on Komenda on comparatively early experience with the project (Seidman, 1978, page 198 fn 120). She states inter alia that "a second sugar plant, purchased from a Czech export agency, appears to have been a dismal failure due to inadequate planning and management. The machinery, previously ordered for Tsito (in Volta Region), was shipped to Komenda after two years of storage (at Ghanaian expense) in a Czech warehouse. Apparently no feasibility studies were made for the new location." Tony Killick recounts a catalogue of problems associated with the setting up and operation of the two projects, many of which were due to short-comings of management at either economy or project level, but particularly the former. (Killick, 1978, see Index page 390 - see below Section II).

The Komenda Sugar Project is located in Central Region about 20 kilometres west of Cape Coast very close to Komenda town. Studies on the viability of the sugar industry in Ghana started in the late 1940s, and investigations on the suitability of the Komenda area for the growing of sugar cane appear to have been started in the late 1950s. On the basis of these investigations it was decided to go ahead with the project although there was not any proper economic assessment of the project's viability. Essentially the reports relating to the project specified the technical requirements for the project to go ahead as planned.

A number of key decisions relating to the project require some explanation. First, the location in the Komenda area has been questioned on the grounds of the sandy and slightly salty nature of some of the soil which is not thought completely suitable for the growing of sugar cane, and on the grounds of the length of the canal carrying irrigation water from the River Pra (26 kilometres involving maintenance and seepage problems). The most likely explanation for the location of the project revolves around the fact that one or more influential persons in decision-making circles had links with Komenda and decided that the project should be located there.

Second, the siting of the factory close to the beach, giving a semi-circular cane supply area increases cane transport costs relative to the more normal circular supply area and requires some explanation. The most likely is that 'hard-standing' was available at the site selected, while alternative sites would have involved more substantial expenditure in the preparation of secure foundations. In addition to the cane transport issue, the proximity of the sea also adds to the corrosion of iron and steel equipment.

Third, the selection of the scale of factory cane crushing capacity at 1000 tonnes per day is at the lower end of the range of time of the investment decision would have been of the order of 2000 tonnes of cane per day, which is approximately the scale of the Asutsuare factory. Whether the scale is related to the amount of cane which it was thought would be available, or to other factors is, by the time of writing, an unknown factor.

Fourth, the supply of the factory equipment by the Czechoslovakian firm of Skoda may be explained by the availability of credit from that source, negotiated on the political grounds that the government was attempting to diversify sources of supply of equipment (as well as other economic links) away from the traditional ones established during the colonial period. The fact that Skoda would have been more familiar with the supply of equipment to the beet sugar industry should not have proved a problem to such an experienced engineering concern. It is also relevant that a technical agreement was made (at about the same time as the signing of the Komenda contract) in 1964 for collaboration between Skoda and a private Indian firm of sugar equipment manufacturers - a relationship which, by all accounts, proved to be quite satisfactory.

Fifth, cane was to be supplied from both a plantation owned and managed by the same organisation as the factory, and from private outgrower farmers contracted to the project. This is quite usual for this type of project, but difficulties, particularly with outgrower cane supply, have arisen in more recent years principally due to irregularities in the running of the factory.

Sixth, a major problem with the project, particularly in its early years, was with a lack of continuity in the management, and a lack of adequate coordination between factory and field management.

Initially, the Komenda Sugar Project was owned by the Sugar Products Corporation (who were also responsible for the Asutsuare project established at about the same time with factory equipment supplied from Poland). Some supervision of the factory building and commissioning programme was provided by a Pakistani firm, Associated Consulting Engineers (A. C. E.) along with the Skoda representatives.

The plantation part of the cane production system was established by the State Farms Corporation. The first crushing was carried out in the 1966/67 season, and in the following season no cane was crushed due to a major maintenance programme on the factory (which would, in turn, have disrupted the cane supply pattern). In 1968 the projects were transferred to the Sugar Products Division of the Ghana Industrial Holding Corporation (GIHOC), while the management of Komenda was taken over by Associated Consulting Engineers. In 1972 an interim Ghanaian management team took over prior to the start of a major World Bank financed rehabilitation project - negotiations for this dated from, by all accounts, as early as 1968. Once the rehabilitation project was confirmed ownership of Komenda and Asutsuare was transferred to an entirely new organisation called Ghana Sugar Estates Ltd (GHASEL) as a condition of the World Bank loan, and management was contracted to a Dutch Company with sugar industry experience in Africa, HVA International. The rehabilitation project ran from 1973 to 1978 after which management reverted to a Ghanaian team, which is still responsible for the running of the project. In a later section of this paper it will be argued that, for a variety of reasons, this rehabilitation project was not successful. However, it is an indictment of the original project design in its entirety that rehabilitation was required at such an early stage in project life.

The content of the discussion which follows contains comparatively little of an economic nature. Part of the reason for this is that with the complexities of the Ghanaian economy an economic assessment superimposed on the technical description and analysis would have made the paper considerably longer. Secondly, the technical and economic performance are very closely linked, so that even with the very limited economic evaluation of the project found later in the paper there is sufficient to indicate that the economic standing of the project is precarious at best. Thirdly, with the data problems associated with the undertaking of a thorough economic evaluation of the project and of the technical alternatives the results would have had considerable limitations.

TABLE 1 – STATISTICS OF KOMENDA SUGAR ESTATE – 1966/69 TO 1981/82

		1966/67	1967/68 (a)	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82
Area harvested	Plantation	445	-	650	947	472	616	551	1,125	1,147	1,310	1,569	1,318	1,180	393	1,139	1,075
	Outgrowers	81	-	336	374	942	1,298	1,019	2,058	1,207	1,232	1,374	1,501	1,555	1,626	1,295	-
	Total	526	-	986	1,322	1,414	1,915	1,570	3,183	2,354	2,542	2,943	2,819	2,735	2,019	2,334	1,075
Cane harvested (m tonnes)	Plantation	31,508		48,128	44,094	21,637	28,713	21,853	34,431	51,092	58,168	38,893	28,518	21,946	17,792	2,107	5,475
	Outgrowers	5,775	-	24,481	19,792	43,390	38,015	38,015	45,829	39,452	42,330	44,040	50,132	46,434	34,076	1,610	-
	Total	37,283	-	72,609	63,836	65,027	59,868	59,868	80,260	90,544	100,498	82,933	78,650	68,380	51,868	3,717	5,475
Cane yield (mt / ha)	Plantation	70.80		74.04	46.51	45.84	46.61	39.66	30.61	44.54	44.40	24.79	21.64	18.60		1.85	5.09
	Outgrowers	71.30	-	72.86	52.92	46.06	37.31	37.31	22.27	32.69	34.36	32.05	33.40	29.86	20.96	1.24	-
	Total (b)	70.88	-	73.64	48.29	45.99	40.28	38.13	25.22	38.46	39.54	28.18	27.90	25.00		1.59	5.09
Sucrose content (%cane) (c)		9.61	-	9.74	11.28	11.89	11.39	9.87	10.31	10.78	10.41	11.18	9.94	10.17	6.09	n.a.	n.a.
Sugar Recovery (%sucrose)	Process losses	42.28	-	41.87	44.31	40.15	37.13	41.17	47.91	35.69	36.08	34.79	41.58	54.63	72.04	n.a.	n.a.
	Sucrose Recovered	57.72	-	58.13	55.69	59.85	62.87	58.83	52.19	64.31	63.92	63.21	58.42	45.37	27.96	n.a.	n.a.
Molasses %cane (d)		5.21	-	4.46	5.88	5.86	5.09	4.76	6.22	5.51	6.16	6.06	5.52	6.75	7.74	14.47	8.56
Sugar produced (metric tonnes)		2,068	-	4,111	4,010	4,626	5,525	3,476	4,318	6,275	6,688	5,862	4,565	3,156	883	32	nil
Molasses produced (metric tonnes)		1,992	-	3,235	3,753	3,808	3,923	2,850	4,994	4,993	6,191	5,022	4,342	4,614	4,016	538	470
Supplementary oil for boilers (metric tonnes)		n.a.	-	n.a.	n.a.	n.a.	n.a.	1,449	5,027	1,049	1,681	2,201	2,813	n.a.	3,328	902	n.a.
Factory downtime	Hours	n.a.	-	n.a.	n.a.	n.a.	n.a.	1,137	n.a.	1,153	1,728	1,508	1,968	2,945	2,780	n.a.	n.a.
	Percent (f)	n.a.	-	n.a.	n.a.	n.a.	n.a.	38.2	43.0	34.8	41.4	39.5	48.8	85.8	65.8	n.a.	n.a.
No. of days in season		n.a.	-	n.a.	n.a.	n.a.	n.a.	124	163	138	174	159	168	143	176	80	n.a.

Source and Notes to Table 1

Komenda Sugar Factory and Estate - thanks are due to the management team who were so painstaking in their compilation of the data on which this table is based.

Notes

a) The factory did not operate in 1967/68.

b) Total cane yield has been calculated based on total cane harvested and total area harvested, rather than on a weighted average of plantation and outgrower figures.

c) Sucrose content of cane has been calculated based on sugar production, sucrose recovery and cane harvested (crushed) data from laboratory reports.

d) The recovery rate is slightly inconsistent with cane harvested (crushed) and sugar production series, but the discrepancy is less than 5 per cent in all cases.

e) The molasses recovery rate has been calculated from the molasses production and cane harvested (crushed) data.

f) Percentage factory downtime is based on total available hours crushing during the season.

II PROJECT PERFORMANCE

Table 1 sets out the major statistics of the technical performance of the Komenda Sugar Factory and Estate from 1966/67 to 1981/82. Section III contains some discussion of economic performance.

A basic factor determining the economic viability of cane sugar manufacturing projects is the length of the crushing season, since the greater the number of crushing days the lower the average fixed cost (including capital cost, administrative costs etc.) per tonne of sugar produced. For a number of reasons it is not feasible to harvest cane in most locations in the tropics for 12 months of the year. The main factor limiting the length of season is the climate, since the process of photo-synthesis which produces the sucrose in the cane requires water and sunshine. Different varieties of sugar cane mature at different stages of the season, and planting patterns determine the approximate harvesting times, but in most cane growing locations the sucrose content in the cane drops sufficiently later in the dry season that it is felt to be uneconomic to harvest and process cane from which it is also more difficult to extract sucrose. (Some supporting data will be found later in this section.) In addition, during parts of the rainy season the fields themselves become very wet, so that running cane transport vehicles in them increases the possibility of bogged down and damaged vehicles in the fields (interfering with cane transport) and of damage to the cane setts, interfering with re-growth. Between 1972/73 and 1979/80 the average number of crushing days per season was approximately 156, with a maximum of 176 and a minimum of 124 days. This is a fairly short season by world standards, but if a sustainable season length of 170 to 180 days was feasible this would be close to the experience of the northern part of the Indian sub-continent where the cane-sugar industry is well established.

TABLE 2 – SUSTAINABLE CANE CRUSHING CAPACITY AND SUGAR PRODUCTION AT KOMENDA SUGAR ESTATE

Season Length	156 days
Theoretical daily crushing capacity	1000 tonnes cane
Average rate of factory downtime (planned and unplanned)	25 per cent
Sustainable cane crushing per season	117,000 tonnes
Sucrose per cent cane by weight	10.5 per cent
Extractable sucrose from 117,000 tonnes cane	12,285 tonnes
Extraction and processing losses	20 per cent
Sugar production per season/annum	9,828 tonnes
Sugar production with 9.6 per cent sucrose in cane and 124 days per season	7,142 tonnes
Sugar production with 11.9 per cent sucrose in cane and 176 days per season	12,566 tonnes

Notes: Tabulation of data presented in text.

A second significant factor affecting economic viability is the sucrose content of the cane. In parts of India and in parts of East Africa, for example, the sucrose may be around 12.5 to 13.5 per cent of cane weight. If the figures from 1979/80 are excluded, the average at Komenda from 1966/67 is approximately 10.5 per cent. This was achieved against great odds, without the level of irrigation originally intended, for example, and with the cane setts being left to produce ratoon crops (see below) for longer than is usual, which also reduces the sucrose content. However, the figure of 10.5 per cent (with a range from 9.6 per cent to 11.9 per cent) is not untypical of the sucrose in cane content found in northern India and in Bangladesh. The economic significance of sucrose content is simply that for any given amount of land, harvesting, transport and crushing time the higher the amount of sucrose available and the greater the sugar production.

Working on the basis of the data in Table 1 it is possible to estimate the sustainable crushing/production capacity of the Komenda project. The results are presented in Table 2. With a season length of 156 days, a designed crushing capacity of 1000 tonnes per day, and a downtime ratio set cautiously at 25 per cent the total cane which can be crushed in any season, on average, would be 117,000 tonnes. With 10.5 per cent sucrose in cane this gives nearly 12,300 tonnes of extractable sucrose, of which 80 per cent ends up as sugar-in-the-bag (allowing for extraction and processing losses). Thus a sustainable sugar production level of 9,828 is reached, as compared with the target of 13,000 to 15,000 tonnes. Using the most favourable and least favourable data for season length and sucrose content the range of anticipated sugar production would be from 12,566 to 7,141 tonnes.

This suggests that the production targets were set on the basis of very favourable assumptions, giving an unreasonably optimistic view of the project performance. This is, in itself, something of an indictment of those responsible for preparing production estimates and of those responsible for perusing documents relating to the project.

In practice, the performance has fallen systematically below even the most modest targets, with average sugar production over the period 1966/67 to 1978/79 of 4557 tonnes (about 46 per cent of the sustainable average) and average cane harvested over the same period of 77,408 tonnes (about 66 per cent of the sustainable crushing average). Table 3 sets out the levels of capacity utilisation year by year. Over the period 1968/69 to 1978/79 the highest and lowest figures for cane crushing capacity were 86 and 51 per cent, and for sugar production 68 and 32 per cent. The average capacity utilisation based on cane crushing was 65 per cent, and based on sugar production 49 per cent. The economic significance of capacity utilisation is, of course, that the higher the utilisation the lower the average costs of production. However, the statistics suggest quite strongly that apart from the problems of ensuring an adequate quantity of cane supply, the extraction and processing losses in the factory were consistently high. The shortfalls of cane availability and on sugar production are best treated separately.

When cane sugar projects are initially established the cane production clearly has to be planned ahead of the commissioning of the factory. The nature of cane production is such that after planting the seed cane yields a first crop known as "plant cane", a second crop known as "first ratoon", a third crop known as "second ratoon", and so on. The usual pattern would consist of plant plus 3 or 4 ratoon crops over a period of 4 to 5 years.

TABLE 3 - CAPACITY UTILISATION - KOMENDA SUGAR ESTATE

Year	Percentage Cane Crushing Capacity	Percentage Sugar Production Capacity
1966/67	31.9	21.0
1967/68	-	-
1968/69	62.1	41.8
1969/70	54.6	40.8
1970/71	55.6	47.1
1971/72	65.9	56.2
1972/73	51.2	35.4
1973/74	68.6	43.9
1974/75	77.4	63.9
1975/76	85.9	68.1
1976/77	70.9	59.7
1977/78	67.2	46.5
1978/79	58.4	32.1
1979/80	44.3	9.0
1980/81	3.2	0.3
1981/82	4.7	-

Notes: The measure of capacity utilisation is based on the data for cane harvested and for sugar production in Table 1 and on calculated sustainable cane crushing capacity and sugar production to be found in the text and in Table 2.

For example, in 1978 the estate plantation cane area at Komenda consisted of the following balance; plant cane 188 hectares; first ratoon 208 hectares: second ratoon 234 hectares; third ratoon 259 hectares; fourth and subsequent ratoons 291 hectares. Thus, in the very early years of operation the full "regular" quantity of cane would not be forthcoming because the cane cycle had not been fully established. An additional factor leading to a "slow" build-up of cane production would arise if the full complement of outgrower farmers could not be negotiated until the project was seen to be properly in operation. The figures in Table 1 show a steady increase in outgrower cane production to 1971/72, 6 years after first crushing. It should be re-emphasised that once land is committed to sugar cane, it would normally be committed for at least 5 years before re-cultivation and re-planting. Thus, low levels of capacity utilisation in the very early years of factory operation are quite usual. (See discussion of Killick below.)

Cane supply in the two years prior to 1968/69 were extraordinary as being of trial crushing in 1966/67 and closure in 1967/68. The performance after 1978/79 was extraordinary since the factory and estate were in considerable decline by that time. The area harvested shows a consistent level of about 1,200 hectares for the estate plantation from 1973/74, and of about 1,200 to 1,500 hectares for outgrower farmers from 1971/72. The World Bank rehabilitation project included a planned increase in the estate plantation area which had initially been set at too low a level as is evident from Table 1. Apart from the inadequate area planted with sugar cane the yield of cane per hectare dropped from an overall level of about 74 tonnes per hectare in 1968/69 to 25 tonnes per hectare in 1978/79. There are a wide range of factors which account for this decline, but this and the restricted area are clearly key factors in explaining the low level of factory capacity utilisation over the years.

The level of sucrose content in cane was somewhat lower than might be considered desirable, but not disastrously so. However, on the issue of cane yield per hectare and sucrose content of cane one question which invites itself on the basis of recent sugar industry development in the Ivory Coast is whether locations further north in Ghana (say in Brong-Ahafo or Ashanti regions) might have produced a better climatic environment for the industry - particularly with regard to hours of sunshine, which is critical in the process of photo-synthesis. In addition, though, the influence of the drought in the mid-1970s has to be allowed for in appraising cane yields and sucrose content in Table 1. Part of the reason for the relative decline of cane production was the failure of the Electricity Corporation of Ghana to maintain electricity supply to effectively activate the irrigation system in the plantation. This particularly accounts for the drop in plantation cane yield in 1976/77 when generating was discontinued at the special ECG diesel plant.

Available factory downtime data show that even given the restricted season length lost crushing time due to breakdowns, mill chokes and lack of cane (through, for example, wet fields) could account for more than half of the high levels of downtime. Over the period 1973/74 to 1977/78 the average time lost (as a percentage of total downtime) due to repairs was 12.3 per cent, due to mill chokes was 3.8 per cent, due to lack of cane was 7.3 per cent, and due to evaporator cleaning was 8.0 per cent. Combined with other factors this gave an average level of factory downtime (41.8 per cent) which is very high for the industry. This is not conducive to efficient factory operations during the actual working period since the boilers depend on a steady supply of bagasse to produce steam - so that supplementary fuel demands are higher the more the stops and starts - and the efficient processing of mixed juice/syrup to produce sugar depends in part on a steady flow of the material.

The amount of supplementary boiler fuel used from 1972/73 to 1977/78 suggests that demands were somewhat higher than for normal operations. The data for process losses and for sucrose recovered (and of molasses produced) suggests severe processing difficulties. Compared with a figure of 80 per cent sucrose recovery which should be comfortably sustainable from the vacuum pan process, the observed average of 58.4 per cent is very low. The figure for molasses production as a percentage of cane crushed (at 5.62 per cent by weight for 1966/67 to 1978/79) is high by world standards - a more normal figure would be in the order of 3.5 - 4.5 per cent. These two sets of figures therefore suggest serious problems in the operation of the factory.

It is useful to consider some of the technical aspects in more detail. The "sugar balance" gives in indication of the breakdown of sucrose losses between various parts of the factory. For the four seasons 1973/74 to 1976/77 the average losses at Komenda were as follows 13.2 per cent in bagasse ("acceptable" 7 to 10 per cent), 1.1 per cent in filter mud ("acceptable 0.5 to 1.0 per cent), 21.0 per cent in molasses ("acceptable" 10 to 15 per cent), and 5.4 per cent undetermined losses ("acceptable 1 to 3 per cent). From this it can be seen that the losses of sucrose at the mill extraction stage were much higher than would usually be acceptable in the sugar industry, as were the losses in molasses through problems in the processing. These "excess" losses amounted to about 10 per cent of available sucrose above the worst that might be accepted as reasonable. It is likely that the explanation is related to equipment maintenance, equipment operation, and raw material quality (especially if intermittent and/or delayed unduly between harvesting and crushing), rather than to the choice of production techniques. It is difficult to be certain about the extent to which there may have been deficiencies in the detailed design or balance of the original equipment specified.

Further, a possible reason for the relatively low levels of cane crushed, for sucrose content in cane figures lower than might have been hoped for at the outset, and for difficulties with processing is that cane was being harvested and crushed at the wrong time of the year, restricting the season length and making some cane overmature. Some evidence is available for the years 1973/74 to 1976/77 to support this line of enquiry. The harvesting/crushing season at Komenda runs from early-November until late-April, with some flexibility depending on weather conditions. In none of the four seasons was any cane crushed in November, implying a sacrifice of about 20,000 to 25,000 tonnes of cane input. In November the sucrose content of cane and the fibre content of the cane are favourable for effective conversion of the cane into sugar (a high fibre content makes extraction of the sucrose more difficult and would, obviously, reduce the sugar/cane ratio as a matter of arithmetic logic). Thus, the failure to crush cane in November represents a sacrifice of at least 1,500 tonnes of bagged sugar. In 1973/74 no cane was crushed in December as well as in November, and crushing continued through May into June. In 1974/75 crushing ended in March, while in 1975/76 and 1976/77 crushing took place only in the months of December to April. The reason given for the late start of the crushing season was that imports of essential spares and other materials were held up due to bureaucratic delays in securing foreign exchange control permission and import licences. This reason is not only plausible, but also suggests that the relevant authorities should have given more careful attention to the timing of industrial requirements (particularly for agro-industrial plants). It is also possible, of course, that requests for exchange control clearance and import licences might have been made tardily.

Whatever the cause(s) of a delayed start to crushing it is significant that as the season progresses the quality of the cane deteriorates due to climatic factors so that the fibre content increases and the sucrose content declines. For 1973/74, for example, the fibre content was 14.44 per cent in January and 19.07 per cent in June. For 1976/77 the fibre content was 15.76 per cent in December and 22.85 per cent in April - sucrose content was 11.85 per cent in December and 7.70 per cent in April. For the four years the average fibre content of cane was 16.96 per cent, and the average sucrose content was 10.67 per cent. If the full season's cane was to be crushed with such a delayed start as that experienced, the level of output would be significantly lower than the potential based on observed cane quality characteristics.

In his study of economic policies in Ghana in the 1960s and very early 1970s Killick (1978) has some illuminating, but in places misleading, comments to make on the progress of the Ghanaian sugar industry. He emphasises, quite correctly, organisational problems which severely hampered the industry. For example, the late-development of the plantations and of irrigation, and poor coordination between the Ministry of Agriculture and GIHOC (page 232) had a crippling effect on planning and performance. His quotation of "profit and loss" of the Komenda and Asutsuare projects for 1964/65 and 1969/70 could hardly be considered representative so early in the life of the projects (page 219), while the citing of a single year's capacity utilisation (page 224) is utterly misleading. In 1966/67 capacity utilisation at Komenda was, as he states, 21 per cent (see Table 3), but over the decade 1968/69 to 1978/79, despite a series of considerable difficulties it averaged 49 per cent (based on sugar produced). Further, Alpine and Pickett's 1980 World Development article comparing the small-scale labour-intensive OPS technology with the large-scale capital-intensive VPS technology is less enthusiastic about the potential economic viability of OPS plants in Ghanaian economic conditions than the earlier 1973 source cited by Killick (page 228). In some senses these comments on Killick's strictures ignore the timing of his writing in the mid-1970s before some of the relevant data and analysis was available. Equally, however, they should not be read as detracting from his overall very valid sceptical view of Ghanaian economic planning and implementation over the period under review.

For those not familiar with the vacuum-pan technology for the production of cane sugar, Appendix 1 sets out a flow diagram of the main processes involved.

Ill TECHNICAL ALTERNATIVES

Given the somewhat disappointing picture which emerges from the description of the project performance in the previous section, the question of whether any technical alternatives might have been selected with a good chance of better performance is obviously pertinent. The discussion will limit itself principally to the factory operations, while some remarks will be made on field operations at the end of the section. Appendix II sets out the basic technical specification of the Komenda factory in 1978.

The first point to be made concerns the scale selected, namely 1000 tonnes of cane per day crushing capacity. As was made clear in the Introduction this is at the lower limit of the scales using the vacuum-pan technology (Tribe, 1979), Bangladesh, for example, being one of the very few countries with plants of the same scale. The most likely explanation for the small scale in the case of Bangladesh is the fact that cane is supplied by some thousands of farmers from very small plots, with a large proportion of the cane being transported over narrow roads in 1 to 1½ tonne bullock carts. This cane supply regime does not apply in Ghana. The problem of the smaller scale is essentially that pro rata the equipment and building costs, and the labour costs, per unit of output are higher than at larger scales - it is principally the capital cost per unit of output which is economically significant (Tribe and Alpine, 1982). The 2000 ted plant built at Asutsuare appears in this context, ceteris paribus, a better economic proposition. Alternatively, it would have been possible to build a plant with a crushing capacity of 1000 tcd, but expandable to, say, 1500 tcd with supplementary equipment. However, the design of the Komenda factory did not allow for the addition of supplementary equipment. One of the reasons for making some factories ‘expandable’ is that the quality and quantity of cane which will be forthcoming is uncertain - once greater certainty has been assured then additional equipment may be installed. It is difficult to understand why this approach to the project design was not pursued in the mid-1960s.

Alternatively, a completely different technology for the manufacture of sugar/sweetener from sugar cane might have been selected. It has been suggested that the small-scale Indian OPS sugar cane processing technology could have been tried, so that in the event of difficulties in obtaining spares etc. the entire processing capacity of, say, 10 smaller scale 100 ted plants would not have been lost at the one time. The problem with this approach is that while valid in the early 1980s for the production of white sugar substitutable for plantation white sugar (of the type produced by the process at Komenda), the small-scale technology had not, in the 1960s, been adapted to manufacture white sugar, but could only produce ‘khandsari’ sugar of a light brown appearance. The likelihood of this ‘khandsari’ sugar meeting consumer resistance initially in Ghana would have increased the uncertainty surrounding the adoption of this alternative smaller-scale technology. Three additional factors are of some significance - first, the equipment for the small-scale technology would have been imported from India so that foreign exchange would still have been required in order to establish production; second, the nature of the small-scale process technology, using a simpler but similar extraction process to the large-scale factories, and using open pans rather than vacuum-pans, is such that processing losses are much greater and more variable than with the larger-scale technology so that the economic case for the small-scale technology is by no means clear cut (Baron, 1975; Tribe, 1983 typescript/mimeo); and third the economic and technical links between Ghana and India were not as well-developed in the mid-1960s as they are in the mid-1980s, making the adoption of the smaller-scale Indian technology unlikely as an alternative to the vacuum-pan technology adopted at Komenda at the time.

There follows a discussion of alternative sub-process techniques in the factory with a view to outlining some techniques which might have been adopted originally when the project was established, or which might be adopted in any further rehabilitation involving substantial equipment purchases. (In this context reference to Appendix II is relevant).

a) Automatic recording of cane weight is preferred by outgrower farmers since it reduces the chances of favouritism/cheating in the recording of cane delivered. The alternative of manual recording is cheaper and less susceptible to maintenance problems, but these factors tend to be over-ridden by the farmers' preferences.

b) For cane-unloading a wide range of systems are feasible, including manual unloading, which removes the need for a feeder table, but increases the required length of cane-carrier/ conveyor extending into the cane yard. The manual unloading technique is widely used in the Indian subcontinent either exclusively, or combined with mechanical unloading. Manual cane-loading in the field would reduce the amount of trash, mud and sand going into the factory with the cane, so that extraction and processing would be more technically efficient. Alternatively, it would be possible to add a "wet or dry cane laundry" to the present mechanical cane-unloading system to provide cleaner cane, but this would further increase equipment cost. Detailed economic analysis would be necessary to verify the viability of the manual loading and unloading technique in Ghanaian conditions.

c) The addition of a cane shredder to the cane preparation equipment (two sets of cane knives) could improve sucrose extraction and reduce crushing time lost through mill chokes.

d) The use of 5 three-roller mills for the crushing of 1000 tonnes of cane per day at Komenda is unusual in the industry, although the use of two turbines geared together to drive the complete mill-tandem is quite usual at this scale. (For example, one 500 bhp steam turbine may drive one large mill or two smaller mills). The 5 mills are, inter alia, more expensive in equipment, installation and maintenance costs than an alternative 1000 tcd mill tandem with only 4 mills. Additionally, if the factory had been designed with the possibility of an expansion to 1500 tcd the usual method of increasing the extraction capacity would have been to leave space in the original lay-out for an increase from 4 to 6 mills. The significance of this factor may be clearer if it is emphasised that the juice extraction sub-process accounts for approximately 15 to 20 per cent of equipment costs (i.e. mills, reduction gearing and steam turbines - Tribe and Alpine 1982 page 12 Table 5). Adjustment to the cane feeding and imbibition systems could improve sucrose extraction.

e) Within the vacuum-pan technology there is little flexibility at the boiler house (steam generation) and power house (electricity generation) sub-processes.

f) In the clarification house there are a number of different methods of treating the mixed juice and syrup, which depend to a large extent on the chemical characteristics of the soil, cane and juice, and on the intended characteristics of the final product (raw, plantation white or refined sugar - grain size etc). Alternatives to the usual double sulphitation would not significantly affect aggregate capital cost, employment or economic performance.

g) For the evaporation of water in the clarified mixed juice there are design variations in the equipment, but these would not radically affect economic performance. With vacuum-pans some alternatives are available, such as internal circulators and automatic boiling controls which improve sucrose recovery and graining, and which were probably not available at the time of the original construction.

h) In the cooling house there are a limited range of technical variations in the design of strike receivers/crystallisers which aid cooling/crystallisation of the massecuite. The distribution of centrifugals so that automatic batch machines handle "A" and "B" sugar, and continuous machines handle "C" sugar, is quite usual for the 1960s and mid-1970s. However, in any re-equipment programme continuous machines might be used for "B" sugar involving lower equipment cost, and lower manning requirements and maintenance costs than batch machines.

i) In the sugar house an alternative to the grass-hopper type vibrating sugar drier is the rotary drum type. The more labour intensive alternatives to the fairly mechanised system of bagging, weighing and closing do not involve employment of substantial numbers of additional workers relative to aggregate project employment. Manual bag handling (using simple mechanical aids - trolleys, pulleys etc) can reduce equipment costs and add slightly to employment.

In general the conclusions of detailed economic evaluation of alternative sub-process techniques in the factory operations (see Tribe, 1981, page 22) supports the generalisation made by Morawetz in his mid-1970s survey article which touched on the issue of choice of technique in LDCs: “peripheral or ancillary activities (materials receiving and handling, packaging and storage) seem to offer greater scope for varying factor proportions than core processes (material processing). It is almost always possible to use people instead of fork lifts and conveyor belts.” (Morawetz, 1974, page 520). However, this issue of alternative sub-process techniques is distinctly different to that of the establishment of a well-balanced set of equipment in this type of agro-processing industry. The annotated technical specification which appears as Appendix II shows that a significant amount of re-equipment and balancing of equipment (e.g. at juice clarification and settling) was necessary in the juice treatment and processing section of the factory during the rehabilitation project.

For the field operations (cane production, harvesting, and transport) a number of basic points may be made, without going into any detail:

i) The approximate 50/50 split between estate plantation and outgrower farmer cane supply is common in the industry. Alternatively any other combination might have been selected from complete plantation production to complete outgrower farmer production. A significant plantation is advantageous since larger scale factories tend to produce seed cane under controlled conditions and to experiment with different cane varieties and with alternative crop-husbandry techniques and regimes. Factories tend to have their own extension services for outgrower farmers in the sugar industry, so that the plantation is then used as the basis for advice to farmers in the proximity. In addition, if fairly large scale irrigation is to be adopted, as was intended at Komenda, a plantation organisation of production is often more suitable, giving better water control than with any independent farmers.

ii) The mechanical cultivation techniques adopted for both plantation and outgrower farmer cane production are consistent with the techniques used in larger scale farming in the surrounding areas. Problems have arisen, by all accounts, in securing sufficient labour for the manual cane harvesting, and in achieving reasonable levels of labour productivity in cane harvesting. It has been suggested that the use of mechanical cane harvesters could circumvent these problems on the plantation and give a more assured supply of cane to the factory. However, it is far from clear that mechanical cane harvesting would ensure adequate cane supplies to the factory since:

a) the combined areas planted to cane in plantation and outgrower sectors was insufficient at the cane yields being experienced to keep the factory fully utilised;

b) interviews repeatedly stressed the difficulty of ensuring adequate cane transport to get the cane to the factory at the appropriate time after it is harvested; and

c) the mechanical cane harvesters would not aid the assuredness of cane supply from outgrowers, who would continue their dependence on manual cane harvesting.

The use of additional foreign exchange to purchase and operate mechanical cane harvesters (which might themselves experience problems with maintenance and spare parts as with other pieces of equipment) in these circumstances could hardly be seen as a solution to the problems. Further, the strong supposition must be that if the cane-cutting labour force was properly organised and supervised, with wages and conditions of service comparable to those applying in the private farming sectors, and with adequate workers' transport, then the cane harvesting problem might be much less pressing. Certainly more detailed economic analysis would be possible given sufficient relevant data, but it is reasonable to be sceptical about the economic efficacy of mechanical cane harvesters.

iii) Cane loading in the fields was undertaken by a mixture of mechanical grab-loaders and manual systems. The mechanical system has the disadvantage of increasing the mud, sand and trash content in the cane as it reaches the factory, and increases the amount of equipment required at the juice settling sub-process (see Appendix II) or in a cane-laundry in the cane yard (see above). Unless labour costs are particularly high manual cane loading is economically preferable.

IV AN ESTIMATE OF KOMENDA'S ECONOMIC PERFORMANCE

Estimation of the economic performance of the Komenda Sugar Factory and Estate, and of technical alternatives is particularly difficult, largely because of considerable price distortions, and a few data gaps. This brief discussion will limit itself to an estimate of the economic value of the Komenda project at 1977 prices - i.e. before the devaluation of the cedi in the 1978 - the estimate will be given in summary form only.

TABLE 4
ESTIMATES OF THE ECONOMIC PERFORMANCE OF KOMENDA SUGAR ESTATE

I) PERFORMANCE "AS FOUND" – 1973/74 TO 1977/78

ANNUAL CANE INPUT	86,684 TONNES
ANNUAL SUGAR PRODUCTION	5,658 TONNES
ANNUAL MOLASSES PRODUCTION	5,019 TONNES

NET PRESENT VALUE – 10% DISCOUNT RATE – 25 YEAR OPERATING LIFE – NEGATIVE C – 59.5 MILLION

REVENUE REQUIRED PER TONNE SUGAR TO COVER ALL COSTS – 10% DISCOUNT RATE – 25 YEAR OPERATING LIFE – C2,174

II) PERFORMANCE WITH FULLER CAPACITY UTILISATION

ANNUAL CANE INPUT	125,250 TONNES
ANNUAL SUGAR PRODUCTION	10,601 TONNES
ANNUAL MOLASSES PRODUCTION	5,019 TONNES

NET PRESENT VALUE – 10% DISCOUNT RATE – 25 YEAR OPERATING LIFE – NEGATIVE C – 43.5 MILLION

REVENUE REQUIRED PER TONNE SUGAR TO COVER ALL COSTS – 10% DISCOUNT RATE – 25 YEAR OPERATING LIFE – C1,383

Note: "Fuller capacity utilisation" differs in this case from that mentioned earlier in the paper (117,000 tonnes cane input per annum) due to the fact that the data base was incomplete at the time the estimates were made. The effective difference in results is minimal.

Using a combination of sources two estimates have been made of the value of the Komenda project. The method used is the calculation of the Net Present Value (Net Worth) using discounted cash flow analysis on the basis of a 25 year operating life, 1977 market prices, and a discount rate of 10 per cent per annum. The technical basis of the first estimate is the performance over the period 1973/74 to 1977/78 for the calculation of the project value "as found" (i.e. as actually operating), while the second estimate makes an attempt to adjust this performance to the fullest feasible capacity utilisation to obtain an impression of the potential as opposed to actual operation. The main elements of the estimates are set out in Table 4. Given the 1977 revenue per tonne sugar (i.e. total revenue from sugar and molasses divided by tonnes sugar produced) of approximately 01000 the actual loss per tonne sugar produced appears to have been in the order of 01200. Even allowing for inflation, it would not be unreasonable to conclude that as the Komenda project was operating over the period 1973/74 to 1977/78 (during the rehabilitation period) the loss per tonne sugar produced was in excess of 50 per cent of the costs.

Given the difficulties with the project it seemed unreasonable to take this "as found" estimate as representative of the potential performance. Therefore, an alternative estimate was made on the basis of a 167 day season (using the data available at the time), and with a considerable reduction in downtime - notably increasing the quantity of cane crushed. This had the effect of increasing the net present value of the project by 016 million, but it remained very substantially negative. More interesting, however, is the substantial drop in the cost of production with fuller capacity utilisation from C2,174 to C1,383 - an improvement of approximately 36 per cent, which would still have left Ghana as a high cost sugar producer in world terms at the ruling rates of exchange. This exercise also illustrates the possibility of making some judgement of whether in the case of a particular project, the level of capacity utilisation or the selection of an alternative technique/technology is more significant in affecting economic performance. In the case of Komenda the level of capacity utilisation appears, on the basis of the partial evidence available, to be paramount. Equally, the estimates suggest strongly that the economic viability of the project is in doubt.

Further comments on some of the more recent economic dilemmas facing the Komenda project appear in Appendix III.

V THE SCOPE FOR REHABILITATION

It has been stated earlier in this paper that the major rehabilitation funded by the World Bank under HVA International management in the period 1973-78 took place much earlier in the life of the Komenda project than would normally be considered necessary. The main problems were found to be based on factory design, inadequate speed of field development (including a low level of cane supply, inadequate irrigation and inefficient cane harvesting and transport) and frequent factory breakdowns. The aims of the rehabilitation were as follows:

i) To expand the area under cane by 508 hectares. At the yields of 1971/72 crop year this would give an additional 23,000 tonnes of cane, bringing total production to about 100,000 tonnes, which would be approximately 85 per cent of requirements at full capacity operation.

ii) To increase cane production per hectare. On the basis of the target cane production area yields would have had to increase by about 17 per cent to 53 tonnes per hectare. This would appear a reasonable objective on the basis of the data in Table 1 above.

iii) To improve the sucrose content of the cane delivered to the factory. In the early 1970s the sucrose content of the cane was at a level of approximately 11.5 per cent. The target of 13 to 15,000 tonnes of sugar per annum from 117,000 tonnes of cane, with 80 per cent factory recovery of sucrose, would require a sucrose in cane content of approximately 15 per cent with the estimated length of season and level of downtime.

This would be an unreasonably high target.

iv) To undertake a pilot irrigation scheme. Since irrigation had originally been part of the design of the project, to plan a pilot scheme after 4 to 5 years of the project life suggests shortcomings in original project implementation.

v) To undertake rehabilitation, modification and additions to cane transport and field equipment, cane yard, mill, workshop and laboratory, and improvements in production techniques in the factory for high efficiency. The breadth of this particular objective suggests that there were severe shortcomings in initial project design, but the general nature of the information available does not allow much more detailed discussion - but see Appendix II for some details on equipment provided in the factory during rehabilitation.

vi) To train efficiently the Ghanaian staff to take over at the end of the period.

vii) To provide housing, health and social facilities for staff and workers.

viii) Provision of extension services by GHASEL and seasonal and medium term credit for farmers through the Agricultural Development Bank. If adequate provision had not been made for vi); vii) and viii) by 1971/72 when the rehabilitation was being planned this reflects rather badly on the design and administration of the project from the outset.

The entire budget for the rehabilitation was US S15.6 million, covering both Komenda and Asutsuare factories, as well as feasibility study work on a new sugar industry project, and the establishment of a small GHASEL head office in Accra. The costings were completed on the basis of a survey of the projects undertaken in 1971, so that by the time that implementation started in 1973, not only had prices risen higher than those specified in the rehabilitation project study, but further deterioration of equipment and field operations had also taken place (reflected partly in declining yields of cane per hectare and sucrose content in cane). Thus, the financial provision was unlikely to have been sufficient to complete the tasks specified in the rehabilitation. In addition, the contract for the rehabilitation scheme included inadequate allowance for inflation, and for changes in exchange rates, during the course of the project. Since the period 1973/78 was a time of relatively rapid inflation in European economies (the main source for imported equipment) this shortcoming was of some significance. In an unpublished very careful estimate Kwadzo estimated that to maintain real purchasing power the rehabilitation would have required 40.42 per cent greater expenditure than that budgeted (personal communication).

The sugar production statistics in Table 1 show a marked improvement between 1972/73 (3,476 tonnes) and 1975/76 (6,688 tonnes) followed by further deterioration through to 1978/79 (Appendix III discusses some aspects of the project since 1978/79). The explanation usually given for the improvement is that up to 1975/76 the foreign exchange in the rehabilitation project allowed the importation of equipment and spare parts to improve productive efficiency. After that year the funds available in the project were severely depleted, and HVA International lost any incentive to further commit themselves since the contract was not renewed as from 1978. Combined, these two factors can largely explain the timing and extent of the deterioration.

The rehabilitation was intended to replace and supplement original equipment in order to upgrade the potential of the project, but not to provide spares for regular repairs and maintenance (which was the responsibility of GHASEL and the Ghana Government). To what extent any shortfall of foreign exchange from this Ghanaian source accounted for part of the deterioration up to 1978 is an imponderable. However, it is certain that considerable dissatisfaction with the way in which the rehabilitation project was prepared and implemented existed amongst all parties in the late 1970s.

It can be seen from the data in Table 1 and from the brief notes in Appendix III that there was a considerable deterioration from the bad situation of the late 1970s through to the latest data which is available for the year 1981/82. The situation with both factory and field equipment as of 1982/83 is essentially a very bad one, and the condition of many of the fields is not, at the time of writing, good. Outgrower farmers have not been supplying cane to the factory at all since 1980/81, and so any further rehabilitation of factory and of field would require re-establishment of the outgrower farmer supply system. Re-establishment of plantation cane supply would require a substantial amount of new equipment, since the usual life span of field equipment is not as long as that of the more substantial pieces of factory equipment. For the factory, the estimate is that 90 per cent of all spares/replacement equipment should be available from non-Czechoslovakian sources, while 10 per cent of the value of required spares would have to be supplied from the original manufacturers. However, even the figure of 10 per cent may be an over-estimate.

The economic viability of any further rehabilitation would depend crucially on a number of factors. The devaluation of the Ghanaian cedi (by a factor of 12.7 against the US dollar between January 1983 and April 1984) makes any project depending on imports of capital equipment less attractive relative to other projects. The increased import price of sugar associated with the devaluation does not necessarily give any protection to the industry since import substitution is not involved in the absence of large-scale sugar imports through official channels. Using a consumption per capita figure of 7 kg per annum (as for the Ivory Coast) the total Ghanaian demand for sugar in more normal circumstances might be in the region of 90,000 tonnes per annum, compared with theoretical production targets of about 35,000 tonnes from Komenda and Asutsuare combined. A further rehabilitation would therefore have to be economically justified largely in terms of the efficient use of resources, the generation of additional employment and income in both agricultural and processing activities, and in terms of beneficial external effects of such a project in a rural or semi-rural location (such as the maintenance of good medical/dispensary facilities, the existence of good workshop and training facilities, and the applicability of agricultural extension services to the surrounding area).

In any rehabilitation there would be some restriction on technology choice, but at some sub-processes a degree of freedom would exist for the selection of techniques different to those specified in the original. (See discussion above Section III).

In addition, if rehabilitation was to be attempted it could be based on a revised view of the season length operationally. Theoretically, crushing could apparently start as early as mid-October, and continue, in normal circumstances until mid or late-April. The statistics cited earlier in the paper show that by April the cane characteristics have deteriorated significantly from those in December/January. It is unlikely, therefore, that the season would be extended on a regular basis beyond the end of April. However, if crushing could start promptly at the beginning of November this would give a clear six month season, with a possible 135,000 tonnes of cane crushed and a possible maximum of just under 11,500 tonnes of sugar per annum on the basis of the same performance data used in arriving at the results in Table 2 for sustainable production levels. Thus, proper attention to the full utilisation of the crushing season could provide a further improvement in technical and economic performance.

VI CONCLUSIONS

Broadly speaking this paper has produced some evidence of poor decision-making, poor project design, poor project implementation and poor project management accountable at both government and at project level. On balance, the major conclusion must place responsibility largely at the governmental level. At the very least, the evidence assembled, both for the original project and for the rehabilitation scheme, indicate that it is necessary to use sanguine estimates of technical performance at the very least, and that uncertainty over these parameters should be explicitly recognised in feasibility studies, preferably in a form of sensitivity analysis. There follows a summary of the major points emanating from the analysis.

1. The original decision on the location and site are open to question, with the suggestion that both may have adversely affected project economic and technical performance.

2. The scale selected at 1000 ted is rather low, and included no provision for subsequent expansion. If a larger scale of production had been selected originally this might have

simply made the project a larger problem than it has been over the years since 1966/67.

3. The technical performance of the factory, and the fact that a major maintenance programme necessitated the sacrifice of crushing in the second crop year, suggests that there may have been some deficiencies in the original factory design. Two particular examples where new or additional equipment was installed during the rehabilitation scheme are at the juice-settling and crystallisation sub-processes.

4. The fact that no proper economic evaluation was undertaken of the original project is partly a reflection of the decision-making structure in Ghana in the mid-1960s, with limited capacity for proper project appraisal.

5. Part of the short-comings in project performance may be accounted for by the substantial discontinuities in the project management and supervision, particularly in its early stages.

6. The production targets for cane and for sugar appear, at several stages, to have been based on very optimistic estimates of cane yield per hectare, sucrose content in cane, and factory extraction and processing losses. This would, of course, give an unduly optimistic estimate of the project's initial viability or of the feasibility of rehabilitation.

7. The limitations of cane production available to the factory forcrushing have occurred partly because of the limited area planted with cane. This is partially responsible for the under-utilisation of factory capacity in the project.

8. The option of an alternative technology based on open-pan boiling of juice may not really have existed realistically in the mid-1960s, when the project was set up, but may be an option in the mid-1980s, given better information flows and economic links with India, and improvements in the small-scale technology.

9. Some alternative sub-process techniques might have been selected originally such as entirely manual cane loading and unloading, a more effective system of cane preparation prior to crushing, and the adoption of a 4 mill tandem extraction system rather than the 5 mills actually installed.

10. The World Bank rehabilitation project (1973/78) appears to have been inadequately funded, but did provide a significant improvement in production and overall project performance until 1975/76.

11. Any further rehabilitation would be affected by the present poor state of both factory and field operations, and would be restricted in the adoption of alternative sub-process techniques by decisions made in the past.

12. To a large extent the poor technical and economic performance of the project has not been due to inadequacies of initial technology selection. Low levels of capacity utilisation have been due in part to short-comings in overall project design and implementation. Increased capacity utilisation would be a major requirement of better economic performance.

13. Based on evidence available the economic viability of the project is seriously in doubt, unless expectation of considerable "external" benefits can be established.

Appendix I

KOMENDA SUGAR FACTORY AND ESTATE
FLOW CHART FOR TECHNICAL DEPARTMENTS

A) CANE PRODUCTION (Plantation and outgrower)

1) Cultivation and Planting - Plant Cane
Weeding and Preparation - Ratoon Cane

2) Cane Harvesting

3) Cane Loading

4) Cane Transport

Other Agricultural Activities
(i) Field Equipment Workshop
(ii) Cane Nursery
(iii) Organisation of Cane Production and Harvesting Schedules
(iv) Agricultural Research

B) CANE PROCESSING

1) Cane Weighing

2) Cane Unloading

3) Cane Preparation

4) Cane crushing for Sucrose Extraction with addition of imbibition water (Crushing Mills powered by Steam Turbines)

5A) BAGASSE TO BOILERS FOR STEAM PRODUCTION (with supplementary fuel - bunker oil)	5B) JUICE TO SCALES FOR WEIGHING
6A) ELECTRICITY GENERATION (Steam Turbines & Standby Diesel Equipment)	6B) HEATING & CLARIFICATION OF MIXED JUICE (Heating with Exhaust Steam; Addition of Lime and Sulphur Dioxide) (Clear Juice goes to 8)
7A) WATER TREATMENT AND CIRCULATION (Condensate from Steam Plus Additional Water)	7B) FILTERING OF SEDIMENT to Produce Filter Mud and Clear Juice Filter Mud to Storage Clear Juice to 8)

8) EVAPORATION

First Boiling with Exhaust Steam from Mills – produces Syrup (after a second sulphitation the syrup goes to 9) Vacuum Pan Boiling

9) VACUUM PAN BOILING

Second Boiling at Lower Temperatures with Exhaust Steam from Mills – produces Massecuite which goes to 10) Crystallisation

10) CRYSTALLISATION
(Cooling/Storage of Massecuite)

11) CENTRIFUGALS

Powered by Electricity with the addition of steam to aid separation of grain sugar and molasses

A + B Molasses to Pans for Re-Boiling	A Sugar to 12)
C Molasses to Storage	B + C Sugars to Pans to Aid Graining

12) COOLING & DRYING

13) WEIGHING AND BAGGING

14) STORAGE

15) ADDITIONAL DEPARTMENTS AT THE FACTORY SITE:
- i) Factory Workshop
- ii) Laboratory
- iii) Administration
- iv) Transport, Security etc.

Appendix II

TECHNICAL SPECIFICATION OF KOMENDA SUGAR FACTORY AND ESTATE

AS AT OCTOBER 1978

1. CANE YARD

a) Cane Weighing - original weighbridge supplied by Transporta of Czechoslavakia, and used for estate cane. Newer weighbridge with automatic print-out supplied by Molenschot and Zoon of Holland, and used for outgrower farmers' cane.

b) Cane Unloading - overhead gantry system supplied by Skoda; crane from Austria, modified with a hoist from Holland.

c) Cane Feeding - original Skoda feeder table enlarged in 1973 with a leveller from Stork added. The table was repositioned to allow feeding from both sides. Two tractors and trailers used in cane yard.

d) Cane Preparation - original Skoda cane carrier with teaser/leveller from Stork added in 1973. Two sets of cane knives from Skoda, with modified, longer knife blades.

2. MILL HOUSE

a) Juice Extraction - five 3-roller mills by Skoda, with feeder rollers for intermediate carriers supplied from Holland. The original mill drive was by two Skoda steam turbines, the first driving mills one, two and three, and the second driving numbers four and five. To prevent overloading of the first turbine, mill number three was transferred to the second turbine drive.

b) Bagasse Handling - elevator and conveyor system for direct feeding to boilers.

3. BOILER HOUSE AND POWER HOUSE

a) Steam Generation - three Skoda boilers, originally with manual water feeding. Modified to automatic Honeywell system, also modified oil burners with Dutch equipment. Considerable use of supplementary furnace oil.

b) Electricity generation - two original Czechoslavakian turbo-alternators. Plans exist to link the factory to the public electricity supply. Two stand-by diesel generators.

4. CLARIFICATION HOUSE

a) Juice Weighing - Skoda juice weighing scale.

b) Juice Heating and Chemical Dosing - four juice heaters. One original sulphur burner and three new from Holland. Originally a manual clarification system, but fully automated with Dutch equipment during rehabilitation.

c) Syrup Treatment - new syrup sulphitating equipment installed in 1973, supplied by Stork, including automatic pH control.

d) Settling - new juice settling tank, Dorman Long, added in 1974 to cope with sand content of incoming cane. Original Skoda clarifier with additional subsider added in 1977 - locally fabricated.

e) Filtration - rotary vacuum filter improved in 1977 by adding new stainless steel screens and back cloths.

5. BOILING HOUSE

a) Evaporation - Skoda quadruple-effect evaporator.

b) Vacuum-pan Boiling - three Skoda Vacuum pans.

6. CURING HOUSE

a) Crystallisation - original "A" and "B" crystallisers: "C" crystallisers cooling system modified by Fletcher and Stewart.

b) Centrifugal Separation - originally Czechoslovakian "A" and "B" centrifugals of which two retained as stand-by equipment. Three continuous centrifugals by Hein Lehmann added in 1975/76. Four original "C" centrifugals by Weston of which two scrapped. Additional Hein Lehmann machine brought from Asutsuare factory.

c) Molasses Handling - automatic weighing scale from Holland installed in 1973.

7. SUGAR HOUSE

a) Sugar Drying and Grading - Skoda vibrating sugar drier and grader.

b) Sugar Bagging and Weighing - two Skoda bagging and weighing machines, one of which was replaced by a Dutch machine in 1978. Two East German sewing machines, one of which was replaced by an American machine in 1972.

c) Bag Handling, Storage and Despatch - conveyor system to warehouse with manual stacking. Maximum storage capacity of warehouse 3,000 tonnes of bagged sugar.

8. ANCILLARY

a) Factory Workshop - manually operated Skoda mill house crane; well-equipped workshop with start made with establishment of small foundry.

b) Laboratory - regular monitoring and analysis at each stage of the process.

NOTE:

The above outline of the factory technical specification was prepared based on interview notes made in October 1978 by the author and Ms Fiona Duguid (now Mrs. Haanen-Duguid). Thanks are due to the management team at Komenda for being so cooperative, and to the Head Office of GHASEL for giving permission to visit the factory. Permission to use data based on this earlier research has been given by the Director of the David Livingstone Institute - the research was financed by the UK Ministry of Overseas Development.

Appendix III

DEVELOPMENTS BETWEEN 1979/80 AND 1981/82

The 1978/79 season represented the close of the World Bank financed rehabilitation programme, and the end of the management contract with HVA International. This meant that as from the 1979/80 season all foreign exchange for spares etc. had to come from Ghanaian sources, were subject to regular import licence and foreign exchange control regulations, and that the entire burden of project management fell onto Ghanaian shoulders when the Dutch expatriates left. Table 1 shows that sugar production fell from 3,156 metric tonnes in 1978/79 to 883 tonnes in 1979/80, 32 tonnes in 1980/81, and nil in 1981/82.

One of the principle reasons for this decline was simply the non-availability of foreign exchange to purchase spare parts for regular maintenance and replacement. This problem has been afflicting large parts of Ghanaian economy in recent years and is by no means a problem solely affecting the sugar industry. At the time of writing large parts of the factory equipment require significant rehabilitation and/or replacement, and sugar production is essentially impossible. As an example of the type of problem which arises we may take the water requirements, which should be no more than 150,000 to 250,000 gallons per day (about 682,000 to 1,137,000 litres per day) - at the rate of twice the specified requirements. The water supply system was designed to use 90 per cent condensate (recycled steam) and 10 per cent make up water, but due to problems with the equipment (including the boilers) only 10 per cent condensate is available with a make-up water requirement of 90 per cent.

The foreign exchange problem also, of course, affects the field equipment maintenance and replacement programme.

Table A. 1 illustrates the position specified by the project management for harvesting equipment in 1980/81:

Table A.1
Harvesting equipment requirements 1980/81

	Requirement	Available
Grab Loaders	2	1
D4 Crawler tractors	2	1
Wheel tractors for cane haulage etc.	40	24
Trailers (estate)	30	17
Trailers (outgrowers)	154	70
Trucks	4	Nil

Source: Komenda Management

On average the equipment available was about half of requirements at normal capacity operation.

The cane harvesting problems extend further than simply the availability of equipment. The labour required for cane cutting at normal capacity operation is stated to be 600 workers (a conservative estimate for 1000 tonnes per day, but a reasonable estimate for the estate production alone). The Komenda management state that no more than 150-350 workers have been available. Since the harvested cane has to be transported to the factory, the shortage of haulage equipment reduces the need for labour to cut cane. In other words, labour supply was probably not the key constraint limiting factory capacity utilisation.

By all accounts, there have been problems in recruiting daily labour for cane cutting, apparently largely due to the fixed daily wage in the public sector operation. In late 1982/early 1983 when Komenda was able to pay 012.30 per day plus a limited bonus, farmers in the private sector in the surrounding area were prepared to pay 030 to 040 per day and give some food as well. If this situation were to be confirmed by more careful research it suggests that even if the harvesting equipment had been available, the labour constraint may have proved to be an obstacle simply because of the rigidity of the wage control system.

A further problem which has affected the cane supply situation has been the official price fixing system. At a time in late 1982/early 1983 when the official cane buying price (i.e. to be paid to outgrower farmers) was 0200,00, farmers were able to ask for, and receive, 0800.00 per tonne from akpeteshie producers in the Komenda locality. Previously, these akpeteshie producers had depended on molasses supply from Komenda, but the decline in the operations of the factory had been reflected in molasses production as well as in sugar production, as can be seen from Table 1. The molasses which was produced in 1980/81 and 1981/82 was apparently largely "sold" to the Asutsuare factory for processing in the distillery attached to the sugar cane processing factory. The pricing arrangements associated with the sale of the molasses have been designed to keep the Komenda factory "ticking over" financially since there is a buoyant demand for the alcohol produced at Asutsuare which can contribute to the support of the industry.

Combined, the arrangements which have applied for the fixing of prices in the industry appear to have been rather inflexible (wages and cane price), while the artificial price for molasses may, or may not, be sustainable. Certainly, independently of the reconsideration of the technical viability of Komenda (and Asutsuare) cane production and processing, any feasibility study relating to a further rehabilitation of the industry would require a careful look at the longer term sustainable prices of both inputs and outputs.

The lack of regular irrigation (particularly for the seed-cane nursery) due to a combination of the failure to establish the permanent link to the national electricity grid, and of lack of spare parts for electricity generating and pumping equipment, has seriously affected the efficiency of the cane production on the estate and by outgrower farmers. This problem has been compounded by the lack of cultivation equipment which has left some outgrower farmers apparently working double or more the usual number of ratoon crops. The relative aridity associated with the prolonged drought through the latter part of the 1970s had a direct effect on cane yields, and also an indirect effect through the encouragement of pests and diseases which adversely affected the quality and quantity of cane produced.

This catalogue of problems could be extended and could also be made more detailed in particular cases. However, there should be sufficient information in this appendix to indicate that the problems have not necessarily been associated with the selection of a particular technology, but have rather been the result of a complex of economic and environmental factors which are not unique to the Komenda project or to the Ghanaian sugar industry.

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CDS/DLI PROGRAMME IN CHOICE OF TECHNOLOGY

KOMENDA SUGAR FACTORY AND ESTATE - A CASE STUDY IN TECHNOLOGY SELECTION AND PERFORMANCE

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