CANE SUGAR

The small-scale processing option

Raphael Kaplinsky

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Frontispiece: Kenyan sugar boiler using the open pan process.

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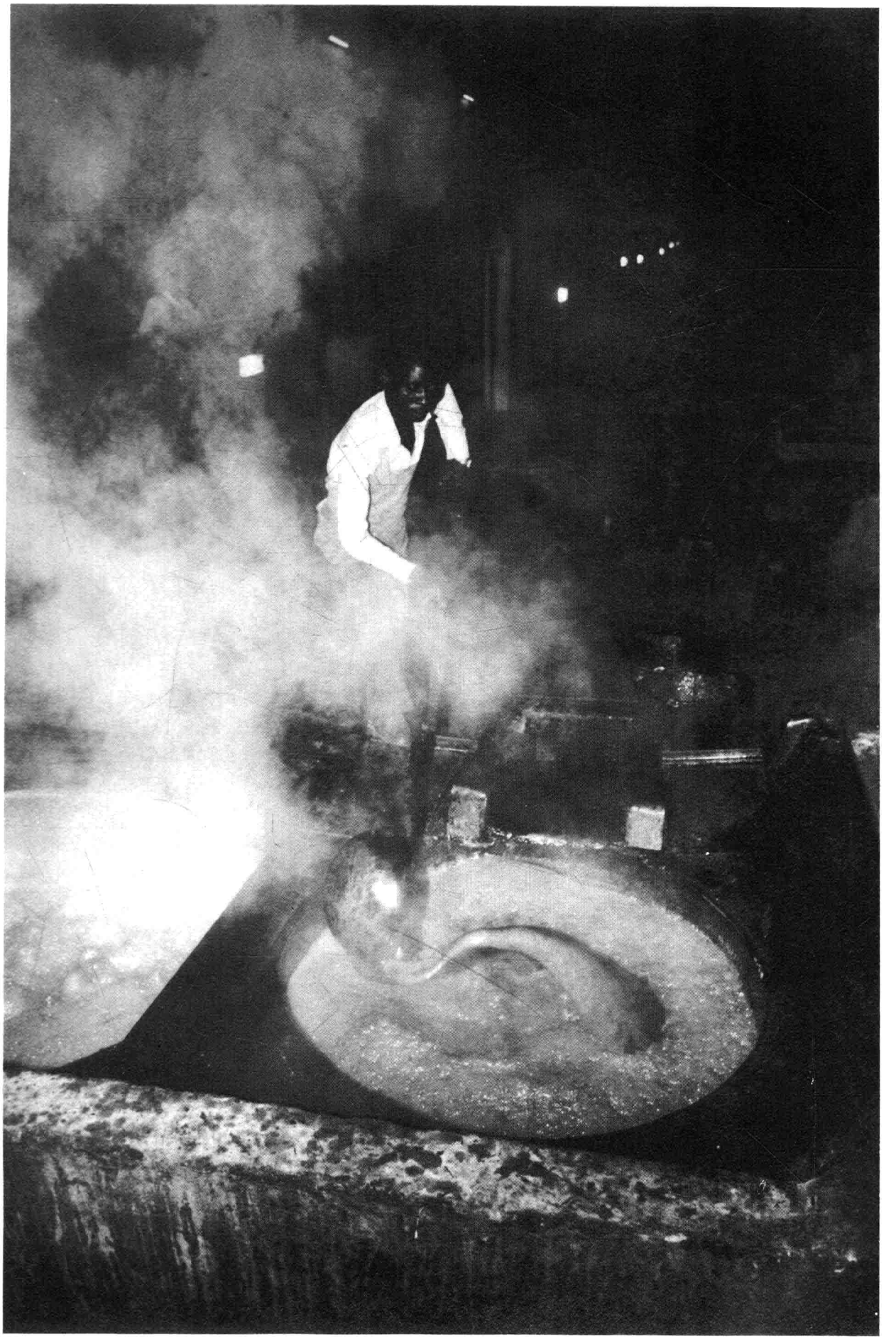

PREFACE

ITDG first became involved in small-scale sugar processing in the late 1970s. At that time there was clear interest in the potential for small-scale factories. Equipment suppliers had realized that saturated sugar markets limited the prospects for supplying many new large factories. Only those countries in the developing world with growing domestic markets wanted more capacity, and they were attracted to smaller size factories which were likely to be easier to locate, finance and operate.

The major drawback to small factories was their lack of scale economies. Building large factories smaller invariably meant higher production costs. At a time when world market prices were often at (or below) the cost of production, the incentive to invest was poor. Consequently few small units were built. At this time ITDG became aware of the widespread use in India of a lower cost, small-scale technique for sugar preparation using the open pan sulphitation (OPS) method. Several thousand units of this type had been established.

ITDG reviewed this phenomenon through support to several projects in India and Kenya, and formally embarked on a sugar programme in early 1984. The Programme formed part of ITDG's activities supported by the Appropriate Technology Fund of the Overseas Development Administration (ODA). The basis for the Programme was the pioneering work undertaken by M. K. Garg at the Appropriate Technology Development Association (ATDA) at Lucknow, India (see Garg, 1979). In collaboration with ATDA, the ITDG programme proposed to diffuse these new open pan white sugar technologies outside India.

The stated objective of the programme was to set up demonstration projects in Bangladesh and Peru to show how farm income and jobs could be created in the rural areas. Meanwhile, work was already underway transfering furnace technology from India to Kenya for the same purpose.

In 1985 the untimely death of M. K. Garg robbed the collaboration of its India connection, and, with particular constraints operating in both Bangladesh and Peru, the programme work was focused towards consolidating the initiative at West Kenya Sugar Company (WKS) in Kakamega, Western Kenya. An ODA review of this project had highlighted the jobs and income which the factory had created.

This factory pioneered the successful manufacture of open pan sugar in Kenya. It followed the failure of the two earlier projects at Kabras and Yala. ITDG continued to support the factory with technical assistance on furnaces, and in 1986 a high juice extraction cane expeller was also installed.

A pre-condition for ODA support had been a comprehensive economic analysis of the technology, and this had been done on a comparative basis with conventional large-scale processes. This analysis predicted that West Kenya would fail in its efforts to establish the technology unless broader government support was forthcoming.

Government support to the factory has so far been minimal, yet even without this the enterprise has proved successful. Factors in this success which were not fully

accounted for in the economic analysis included quality of management, versatility of product mix and the attractiveness to farmers of small factories.

ITDG was concerned that these factors might be exclusive. However, further investigation has shown that capable entrepreneurs are interested in investing, that the factories can exert the necessary influence over the local market for cane and sugar products, and that the social impact of cane agriculture is positive.

This last point was an important one to ITDG. Sugar cane has been associated in some way with most forms of labour and land exploitation. However, where cane is grown within the existing agricultural system by independent farmers it does appear to create wider opportunities for participation by the local community. The cash earned is an important source of investment for the families in their children and their homesteads.

ITDG thus remains keen to support the spread of this technology. However, the conclusions of the early analysis remain largely correct — government policy must be supportive of small-scale enterprises. The reasons for this relate to the structure of costs in sugar production. Small factories do not have the processing scale economies to produce cheap sugar. However, they do have lower agricultural costs and lower distribution costs. This means that sugar can be put in the shops for the same price, but only if sector policy recognizes this structural difference and thereby creates an environment which favours small-scale investment.

Having collected over the years a considerable amount of information and evidence on small-scale sugar, ITDG felt it would be useful to turn to a wider forum to consider the future of small-scale sugar processing, and hence organized a conference on the subject, held at the Institute of Development Studies, University of Sussex, Brighton, UK, from 10-11 September 1987.

These proceedings contain the papers presented at the conference together with several commissioned since then. They explore the background and current situation of small-scale sugar processing, and present some options for the future of the industry. The proceedings are presented in two parts. The first contains a summary of each of the papers, and is designed to facilitate a quick reading by those wishing to obtain an overview of the issues under discussion.

The second — and larger — part of these proceedings contains all of the papers in full. This part can broadly be divided into seven major sections. The first comprises a statement of the issues under discussion. This is followed by a description of the various sugar processing technologies, with particular emphasis on OPS. The third section discusses the global context within which each country situates the development of its sugar processing sector. Next there are a series of papers addressing scale economies in sugar processing, both in relation to vacuum and open pan processing. The fifth section comprises a detailed recounting of the experience of OPS technology in Western Kenya. This leads to a section which addresses the policy implications for developing country governments. A final paper draws out the major conclusions, focusing particularly on the policy implications for governments, ITDG and other non-government organizations. It is in the development of appropriate policies that the future of small-scale sugar processing now lies.

Following on from the conference, ITDG has decided to continue the sugar programme for a further year to investigate the potential for dissemination in East Africa. Positive indications have now been received from the Governments of both

Kenya and Tanzania. These will be developed by the programme into a firm basis for establishing a small-scale sugar sector. The conference was an important step on this path towards ITDG's goal of equitable rural development through small-scale enterprises.

Raphael Kaplinsky and Ian McChesney

REFERENCE

Garg, M. K., *Project Report and Feasibility Study of Appropriate Technology on Mini-Sugar (OPS Khandsari)*, ATDA (1979).

CONTENTS

PART ONE

SUMMARY OF CONTENTS

SECTION A: INTRODUCTION

Overview

The paper begins by addressing the question of why ITDG should be involved with sugar at all. Justification is provided in terms of the potential benefits to farmers, mill workers, mill owners and the government (often the mill owners anyway) of particular forms of organization of the industry. As a minimum, this should involve supply of cane from smallholdings.

The issue of large- versus small-scale sugar production is examined from a range of perspectives. These include technical performance, economies of scale, financial and economic viability, social impact and the impact of government policy. Discussion is referenced to the papers which follow in the main body of the book. Small-scale open pan methods are capable of producing a product mix of either sugar and liquid molasses, or sugar and solid molasses. Large-scale vacuum pan technology is considerably more efficient at processing cane to sugar, owing to technical economies of scale. However, managerial and distributional diseconomies, associated with the problem of ensuring sufficient cane supplies for crushing, can offset the technical economies.

Given current cane and sugar prices in Kenya, both vacuum pan and open pan processes are only marginally financially viable, though vacuum pan may be rather more profitable than open pan where both technologies operate at full capacity. In economic terms, vacuum pan technology makes more efficient use of cane supplies while open pan is more sparing in its use of capital. Economic analysis somewhat improves the performance of open pan relative to vacuum pan but, given the low world market price for sugar, again viability is no more than marginal.

Evidence regarding social impact in terms of the effect on the economic welfare of food security for, and nutritional status of, low income groups is mixed. There are clear signs that farmers supplying an open pan sugar factory are more likely to have smaller land holdings and engage in multiple cropping than are farmers supplying vacuum pan mills. Concentration of land holding and increasing income differentials are also likely to be associated with vacuum pan factory outgrower schemes. On the other hand there is little evidence of a decline in nutritional status among such outgrowers, and differences in social impact between small-scale and large-scale schemes may be due, at least in part, to different periods of operation. Vacuum pan plants have been established much longer than open pan in Kenya; thus the social impact of vacuum pan units may be expected to be more clearly articulated.

Government policy has had, and will continue to have, a significant influence on the choice of technology within the sugar industry. For the present, policies tend to favour the large mills. In Kenya these are mainly government owned, and are therefore more

easily able to absorb financial deficits than small private mills. Given the narrow processing margins in Kenya (the consequence of government-set prices for both cane and sugar), there is little incentive for private investment in small- or large-scale sugar. Sugar production is thus less than potential in both large- and small-scale sectors. The removal of excise duty would be sufficient to make small-scale open pan sulphitation (OPS) production profitable.

It may not be enough, however, just to indicate the appropriateness and profitably of OPS sugar to have policy changed. Yet without some change in policy, there is little future for OPS in Kenya.

Mel Jones, Intermediate Technology Development Group

SECTION B: CANE SUGAR TECHNOLOGY

Introduction to processing techniques

This paper sets out the various stages of sugar separation, and the associated derivation of the efficiency terms used subsequently in this book. The distinction between the 'vacuum pan' and 'open pan' methods is explained, as are the reasons for their differing levels of effectiveness. The role of cane quality and capacity utilization in determining these figures is also noted. Open pan systems are particularly sensitive to the skill of the operator, whereas vacuum pan systems respond better to improved management.

The paper also looks at the energy balances of these two sugar processes. While vacuum pan plants tend towards fully integrated energy systems that run entirely on bagasse, open pan plants use a range of energy sources in addition to bagasse to satisfy their heat and power requirements.

In conclusion, the paper sets out in tabular form the range of technologies that might be considered for the 'front' and 'back' ends of the sugar manufacturing process.

Alex Bush, Intermediate Technology Development Group

The history and development of the technology

This paper touches briefly on the early history of cane sugar from its first recorded manufacture through more than three thousand years until the seventeenth century AD. The primitive technology varied slightly from place to place, and was based on herbal and other methods of clarifying the raw juice which were handed down through the generations. It is believed to have originated in the Far East, whence it spread across Asia to Egypt and the islands of the eastern Mediterranean.

When chemistry became an exact science, the process began to be rationalized. By the early 1700s, when European nations were establishing colonies in the Western hemisphere and the East Indies, there was a uniformity of technique and a growing understanding of factors which could affect the purity of the product. It was particularly observed that juice became acid if left standing for long, and that the crystallized mass was made darker in colour by contact with heat. Lime was generally used to neutralize the acid, and the only way to offset colour formation in the open pans was by bleaching with sulphur dioxide.

Most of the product was shipped to the colonial powers, and with increasing prosperity the demand for both greater volume and better quality brought pressure to bear on the industry to become more scientific. The Napoleonic Wars intervened, but in their aftermath at the beginning of the nineteenth century, the newly independent United States of America, enlarged by the purchase of Louisiana from France, saw the

development of the vacuum pan to crystallize sugar with much less formation of colour than before.

The French, meanwhile, had turned to the alternative of beet sugar to counter the maritime blockade of their seaports. Although the technology was similar, the fuel supply was lacking. Intensive research led to the establishment by Rillieux of the principles of multiple effect evaporation, which made the beet industry economically feasible although still not competitive with cane sugar which was largely produced by slave labour.

Victory for the North in the American Civil War led to the outlawing of slavery and the cane industry had to mechanize. In the 1870s it adopted multiple effect evaporation, the centrifugal machine, and steam engines to drive conveyors and lift the juice and create the vacuum for low temperature crystallization. The shape of the modern sugar factory was thus established. Thereafter, any improvement in efficiency was simply achieved by increasing its size and throughput.

The twentieth century has seen the introduction of the diesel engine, electric power and lighting, automation, instruments for measuring and controlling the process, and even computers. But there have been no changes in the fundamental technology.

The paper concludes by suggesting that modern technology should be put to the test of devising a cane sugar factory which provides for the advantages of vacuum pan technology, but at significantly reduced rates of output and with less automated technology.

John Pearson, Independent Sugar Consultant

SECTION C: THE GLOBAL CONTEXT

The world sugar market

World sugar production and consumption are currently running at more than 100 million tonnes, but most of this is consumed in the country of origin. There are also large blocks sold under what are termed 'special arrangements', which are commercial pacts established within a general political understanding. Within these pacts, trading is for the most part at special prices. The balance of sugar which passes from one country to another constitutes the world market, and even including sugar moving in one direction as raws and then in another as refined, the total is still only of the order of 19 million tonnes.

Clearly, world market sugar constitutes only a small percentage of the total. In most years there is a surplus. Consequently, world market prices are low, sometimes falling to less than the cost of production.

Producers look at their sales as an overall package, and can accept low prices from the world market if they can be averaged with better prices received from special arrangements and domestic sales. This tends to perpetuate the existence of surpluses.

Attempts have been made to limit the availability of sugar coming on to the world market through the operation of international sugar agreements (ISAs). Generally these have not been successful. Currently only an administrative ISA operates, and it is in no position to influence the market. There are some hopes that co-operation may develop out of the current General Agreement on Tariffs and Trade (GATT) discussions.

Rodney Goodwin, C. Czarnikow Ltd.

The structure of world production and consumption

Sugar manufacturing is an ancient industry, now carried on over a wide range of physical and economic conditions in more than a hundred countries of every size and population; in some exclusively for internal consumption, in others primarily for export. Sugar can be had in various forms — liquid or solid, impure or refined, granular or in lumps — and there are different methods of making it. The bulk is obtained from sugar beet and sugar cane, the former in temperate climates and mainly in developed countries, the latter in tropical and subtropical regions predominantly belonging to the Third World. Both crops are grown on all kinds of farms, from smallholdings to large agribusinesses.

Processing technology underwent a revolution in the nineteenth century, following the advent of steam which paved the way for the progressive enlargement and centralization of factories. But even today, sugar is still made in tiny rural establishments as well as in very large industrial plants. In several countries, small sugar producers, employing both old and new techniques, constitute an important sector of the industry.

Sugar manufacturing offers a choice between small-scale and large-scale systems and within the former, between open pan and vacuum pan boiling. In addition, there are various levels of sophistication of equipment and processes available in all three options. The diversity of sugar production systems existing in practice reflects the fact that no one way of making sugar is appropriate to all circumstances. Scale economies of larger vacuum pan factories notwithstanding, proximity to the raw material supply and market or exemption from government regulations may give small open pan sugar producers a commercial advantage.

Comparisons of the two basic technologies and of different scales of operation involve a complex set of trade-offs. These arise from differences in capital and labour intensities, lumpiness of investment, time profiles of costs and returns, relative risk, fuel consumption, product yield and product quality — among other factors. Market size and consumer preferences constitute important considerations. The need for careful appraisal of the alternatives is confirmed by the failure of several large sugar projects in recent years, and the delays and cost over-runs experienced in the execution of others. There is considerable scope for the application of small-scale sugar processing techniques, particularly in areas of limited cane supply and in countries with small or fragmented internal markets.

Gerry Hagelberg, Independent Sugar Consultant

SECTION D: THE ISSUE OF SCALE ECONOMIES

Scale considerations in sugar production planning

The paper reviews evidence of detailed research on scale economies in the larger-scale vacuum pan technology-based sector of cane sugar production. It concludes that on the grounds of economizing on scarce capital, scarce foreign exchange and scarce highly skilled labour and of utilizing domestic resources as intensively as possible, as well as of production costs, the minimum economic size for this technology is probably of the order of 3,000-5,000 tonnes of cane input per day. Non-intrinsic scale factors tend to support this conclusion, particularly if low levels of capacity utilization are uniformly experienced at all scales. Other non-intrinsic factors (including, for example, cane transport costs) do not systematically favour larger- or smaller-scales.

There is also some consideration of the impact of differential price and tax structures between the larger-scale (vacuum pan — 1,250 tonnes cane input per day and over) and smaller-scale (generally open pan below 200 tonnes cane input per day) sub-sectors. Differences in operating conditions mean that in many cases (not only in India) the two sub-sector scale/technology types are able to co-exist profitably, with favourable effects on the employment and income generation and rural development objectives of economic policy.

The paper ends with the suggestion that perhaps the ultimate factor determining the degree of success of individual sugar projects (regardless of scale or of technology type) is the effectiveness of management and co-ordination in the planning, implementation and operation phases of the project cycle.

Michael Tribe, Project Planning Centre, Bradford University

New cane extraction technology for small-scale factories

This paper focuses on the application of diffuser technology to high efficiency sugar processing. Work on large-scale units is described, followed by descriptions of performance at the pilot unit installed in Tanzania by De Danske Sukkerfabrikker (DDS).

At the conference, a video of the small-scale DDS diffuser installation in Bangladesh was shown to confirm the conclusion that small plants of this type can be made to work, and made to work efficiently.

Alan James, Sugar Knowledge International Ltd.

Realizing scale economies

For the purposes of this paper, 'large-scale' has been assumed to mean a capacity of at least 1,000 tonnes of cane per day. 'Full production' has been assumed to mean operating at 90 per cent of net available time.

The key to operating a large-scale sugar factory at full production is to have an adequate supply of mature, fresh cane delivered to the factory throughout the harvesting season. The paper examines briefly the main factors which contribute to success or failure in achieving reliable cane availability, including the particular problems of cane supply build-up in a new project. Reference is made to the special circumstances of small farmers.

The factory itself must be appropriately designed, well-maintained and operated by staff who are adequately trained and motivated.

Overall, the view taken is that capacity utilization is achieved by good planning and organisation, with the greatest emphasis on growing and delivering cane.

George Moody-Stuart, Booker Agriculture International Ltd.

SECTION E: IMPROVED OPEN PAN PRODUCTION — A DECADE OF EXPERIENCE

Improvements in open pan sulphitation technology

This paper sets out to review the scope for improving the open pan sulphitation (OPS) technology for white cane sugar manufacture, as observed by ITDG through its involvement in OPS technology development in India and dissemination in Kenya.

The review defines briefly the performance of the technology itself, but necessarily starts with an overview of the prevailing circumstances in agriculture, employment, infrastructure and the investment climate which have encouraged the invention and adoption of the technology. These factors then provide the essential framework within which the improvements have to be designed and incorporated.

The paper concludes that below 200 tonnes per day cane processing there are new, improved OPS technologies—the expeller and shell furnace—with the potential to improve operating performances. This is particularly the case in terms of milling efficiency—up to 85 per cent from 75 per cent—and fuel balances, but further work to supplement current efforts is needed to raise boiling house recoveries above the 75 per cent usually obtained. Rendements therefore lie in the range 7-9 per cent for the old and improved processes respectively, depending on cane quality.

Beyond these levels of operation, there are few obvious economies of scale in open pan processing and therefore little access to lower operating costs—and improved profits—through expansion. This is an important consideration and probably confines the role of the technology to situations where cane supply is either in intermittent surplus (some parts of India), where total cane supply is limited by geographical considerations, or where cane supply is to be built up for other, larger, sugar investments.

Ian McChesney, Intermediate Technology Development Group

Economic viability of small-scale sugar production in Kenya

This paper considers the financial, social and economic viability of sugar production in Kenya. It is based upon data acquired from the West Kenya Sugar Company and estimates of production costs for a range of other types of plant. Five technological options are considered: large-scale vacuum pan (3,600 tcd), medium-scale diffuser technology (450 tcd), small-scale open pans (100 tcd) producing sugar and molasses, small-scale open pans (100 tcd) producing sugar and solid molasses, and small-scale (45 tcd) jaggery production.

Unlike the very small plants producing jaggery, none of the technologies available for sugar production can operate profitably at current prices. However, the vacuum pan (VP) plant should be able to produce sugar at a slightly lower cost than open pan sulphitation (OPS), but VP is more sensitive to sub-optimal capacity utilization. If shadow prices are utilized for both inputs and outputs (measuring these at their foreign exchange opportunity costs), the relative disadvantage of OPS over VP is narrowed. However, even when shadow prices are utilized, none of the three sugar technologies is able to operate profitably at existing prices. A consideration of social parameters probably narrows the gap between OPS and VP.

On this basis, and given the approximate nature of the costings involved, it is difficult to conclude definitively that VP is the optimal choice — especially when economic and social factors are taken into account. It is reasonably clear, however, that diffuser technology is uncompetitive in all major respects.

The paper concludes with a discussion of the policy options open to the expansion of small-scale sugar production in Kenya. It considers a range of incentives and exemptions which might act to tilt the choice of sugar technology in an appropriate direction.

Edward Mallorie, Consultant