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08855

Distr.
LIMITED
ID/WG. 282/75
9 October 1978
ENGLISH

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

# INTERNATIONAL FORUM ON APPROPRIATE INDUSTRIAL TECHNOLOGY

New Delhi/Anand, India 20–30 November 1978

## WORKING GROUP No.4

## APPROPRIATE TECHNOLOGY FOR THE PRODUCTION OF SUGAR

CHOICE OF TECHNOLOGY IN THE SUGAR INDUSTRY

Background Paper

id. 78-6909

# CHOICE OF TECHNOLOGY IN THE SUGAR INDUSTRY

by

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## 1. Introduction

In this note a comparative cost analysis of two technologies for producing sugar has been attempted. The two technologies examined are the Open Pan Sulphitation (OPS) process and the Vacuum Pan Sulphitation (VPS) process. The sugar produced by the former process is normally referred to as 'khandsari' and the latter as 'white sugar' or 'mill sugar'.

The note is divided into the following sections : (i) background information on the sector, (ii) description of the techniques, (iii) economics of the techniques, and (iv) government policy.

## 2. Background

Production. Annual sugarcane production in India is around 1400-1500 Lakh tonnes. The major producing States are U.P., Maharashtra, Tamil Nadu and Andhra Pradesh. Their shares in all-India production are 42, 13, 9 and 8 per cent respectively.

Sugarcane is utilised for the manufacture of gur, khandsari and white sugar. A small amount is used for feeding, chewing, etc. The utilisation of sugarcane in 1975-76 is shown in Table 1.

TABLE 1

UTILISATION OF SUGARCANE, 1975-76

| | (Lakh Tonnes) |
|---|---|
| A. For Production of Gur | 654.51 (45.87%) |
| B. For Production of Khandsari | 184.62 (12.93%) |
| C. For Production of VPS Sugar | 418.50 (29.33%) |
| D. For feeding, chewing, etc. | 169.42 (11.87%) |
| Total Production | 1427.05 (100%) |

* Prepared by Shri C.R. Reddy under the guidance of Shri Nitin Desai and Prof. Raj Krishna. The linear programming model specified by Prof. Raj Krishna

Production of gur, khandsari and VPS sugar in major cane producing States in 1975-76 is shown in Table 2.

TABLE 2

PRODUCTION OF SUGARCANE, GUR, KHANDSARI AND WHITE SUGAR 1975-76

| | Sugarcane ('000 Tonnes) | Gur (Lakh Tonnes) | Khandsari (Lakh Tonnes) | VPS Sugar (Lakh Tonnes) |
|---|---|---|---|---|
| Uttar Pradesh | 583.59 | 28.09 | 9.87 | 11.64 |
| Maharashtra | 188.70 | 3.30 | 0.04 | 16.05 |
| Tamil Nadu | 119.36 | 12.49 | 0.01 | 1.02 |
| Andhra Pradesh | 103.32 | 4.85 | 1.26 | 3.26 |
| Karnataka | 97.19 | 5.43 | 0.23 | 3.61 |
| Total | 1092.16 | 54.16 | 11.41 | 36.38 |
| All-India | 1427.05 | 64.11 | 12.00 | 42.62 |

It can be seen that U.P. is the largest producer of gur and khandsari but it is second to Maharashtra in VPS sugar production.

In 1976-77 production of VPS sugar was 48 lakh tonnes and of khandsari 12 lakh tonnes.

Employment. Data on employment in the khandsari sector is not available. However, using the employment norm (42.87 mandays/tonne of sugar), the approximate employment in terms of mandays in 1976-77 would be about 514.44 lakh mandays. Similarly, employment in terms of mandays in the VPS sector is estimated as 396.68 lakh mandays. Thus total employment in the sugar industry is approximately 911 lakh mandays in 1976-77.

Sugarcane production in different States is shown alongwith the prevailing personday unemployment rates in Table 3. (Regionwise details are in Annexure 3).

TABLE 3

UNEMPLOYMENT RATES IN SUGARCANE GROWING AREAS

| No. | Unemployment Rate | Sugarcane Production (1972/73) | Share in All-India Production |
|---|---|---|---|
| | (Per Cent) | (Lakh Tonnes) | (Per Cent) |
| 1. | 15 | 11.66 | 0.95 |
| 2. | 11-15 | 228.19 | 18.49 |
| 3. | 6-10 | 1295.23 | 23.92 |
| 4. | 5 or less | 698.98 | 56.64 |
| | | 1234.06 | 100.00 |

Sources: 1. Personday Unemployment Rates from National Sample Survey: 27th Round

2. Sugarcane Production from Regional Levels of Agricultural Development in India, Centre for Regional Development, Jawaharlal Nehru University and Perspective Planning Division, Planning Commission.

It is clear that the bulk of sugarcane is grown in areas of relatively low unemployment.

## 3. Description of Technology

Manufacturing Process: The manufacture of white sugar can be divided into the following stages:

(i) Extraction of juice from sugarcane.

(ii) Clarification of juice.

(iii) Evaporation and concentration of juice into massecuite.

(iv) Formation of crystals.

The basic difference between the OPS and VPS processes is that while the evaporation of juice in the former is carried out by boiling under atmospheric pressure (hence the name 'Open Pan'), in the latter it is done in a vacuum and hence under lower pressure. The other main difference is that in the VPS process, juice is moved between processes by power driven pumps, while in the OPS process the movement is largely manual.

The sugar produced by OPS units is commonly referred to as 'khandsari'. In the OPS process, the juice is clarified by sulphitation and not with vegetable matter, as in the traditional process. Hence it is also called 'improved' or 'sulphur khandsari', while traditional khandsari is referred to as 'desi khandsari'.

Thus, there are four technologies for processing sugarcane : (i) gur technology, (ii) traditional or desi khandsari technology, (iii) open pan sulphitation process for khandsari production, and (iv) vacuum plan sulphitation process for white sugar production.

Although gur production utilises about 50% of sugarcane production in India and gur is an important energy food in the rural areas, the economics of its production has not been examined in this note since it is not a simple substitute for white sugar. Traditional or desi khandsari production is believed to be negligible at present and hence it has also been excluded from this study. (In this note, whenever the term 'khandsari' is used, it refers to improved or sulphur khandsari only. Sugar produced by the VPS units is referred to as VPS sugar or mill sugar).

Quality of Output. A comparison of two or more technologies would be meaningful only if the output of the two technologies is more or less comparable. Hence, it is necessary to examine the difference in quality, if any, between khandsari and VPS sugar.

Sugar is generally classified according to colour and grain (crystal) size. The colour is denoted on a scale ranging between 25 and 30, with 30 denoting the best (whitest) quality. Grain size is classified as either A, B, C, D or E, with A denoting the largest grain size and E the smallest. A-30 sugar, i.e. sugar with the whitest and largest grain, is considered the best variety.

Approximate quality-wise distribution of the output of khandsari and VPS sugar is available. About 75% of VPS sugar production belongs to categories C30 and D30 whereas nearly 90% of khandsari production is in categories C&D29 and C&D27. Thus, in general khandsari appears to be comparable with VPS sugar in terms of grain size but not in terms of whiteness. However, in terms of purity, C&D 28 khandsari is 99.4% pure, while C-30 VPS sugar is 99.9% pure.

The difference in quality is reflected in prices. The average open market wholesale prices of khandsari and VPS sugar are given below:

TABLE 4

AVERAGE WHOLESALE PRICES OF VPS AND KHANDSARI SUGAR, 1976-77

| | VPS Sugar | Khandsari Sugar | Difference |
|---|---|---|---|
| | (Rupees/Quintal) | | (Per Cent) |
| Delhi | 421 | 350 | 17 |
| Kanpur | 416 | 308 | 26 |
| Bombay | 422 | 314 | 26 |

Note : The difference in prices has ranged between Rs.70-Rs.130 per quintal over the past few years in these markets.

The difference in Bombay is about Rs.100 per quintal i.e. nearly 26% of the VPS sugar price. The difference in Delhi is smaller at Rs.70 per quintal, i.e., around 17% of the VPS sugar price.

Regarding consumer acceptance, it appears that sugar with white crystals is preferred and hence khandsari is at a disadvantage. But it is learnt that since khandsari is cheaper and the difference in purity only marginal, it is used to a large extent in confectionaries and bakeries. The yellowish colour of khandsari might make it unacceptable for household consumption, but not for confectionary manufacture. Household consumption of khandsari is largely restricted to mofussil areas. However, no reliable

data about the marketing of khandsari is available to substantiate these opinions.

To sum up, since both khandsari and VPS sugar serve as sweetening agents and since the difference in real quality (i.e. purity) is only marginal, it would be reasonable to assume that they are basically similar products and hence a comparative economic examination of the two technologies is justified.

Efficiency of the OPS Technology. From an economic point of view one crucial difference between the two technologies is the difference in the recovery rate of sugar from sugarcane. Recovery rate is the ratio of the weight of sugar produced to the total weight of cane crushed. OPS units have a lower recovery rate. This lower recovery rate can be attributed to the following reasons:

(i) Losses in Milling and Crushing. Milling efficiency measures the amount of juice extracted as a proportion of total available juice in sugarcane. In the OPS units the maximum milling efficiency is 80% as compared to 90% in the VPS units. This 10% lower efficiency decreases the recovery rate by 1%. Even this (80%) level of efficiency is rarely achieved due to the desire of the factory managers to crush a larger quantity of cane at the expense of a higher extraction rate. Rollers are frequently "loosened", and though this enables a larger amount of cane to be fed through the rollers, the rate of extraction of juice, and consequently the recovery rate, is lowered. The Planning Research and Action Institute, Lucknow, and the Appropriate Technology Development Association of Lucknow are currently experimenting with an expeller for crushing cane which in trials has shown a milling efficiency of as much as 87% - 88%. An additional advantage of this expeller would be its lower cost. Its cost is estimated as Rs.80,000 while the crushers currently in use cost Rs.1,25,000 each.

(ii) Losses in Boiling (Inversion Loss). Inversion loss is due to the conversion of sucrose (or cane sugar) under certain conditions into two molecules of glucose. The glucose is lost in molasses. Hence the higher the amount of inversion, the lower is the recovery rate of sugar.

Two important factors which affect inversion are boiling temperature and the time taken in boiling. Up to a temperature of 60° C, the inversion rate of neutral juice is almost nil. Beyond 60° C, for every 10° C increase the rate of inversion increases 2-2.5 times. In the OPS process, the boiling point of the juice is as much as 110° C and hence the inversion loss is quite significant. The recovery loss due to this inversion is as much as 0.5%. The VPS process is distinctly superior as the juice is boiled under reduced pressure with the temperature maintained between 60° C and 65° C. Reduction of inversion loss in the OPS process by lowering the boiling point would be difficult to achieve as the juice is boiled

under normal atmosphere pressure (unlike the VPS process). However, the loss could be reduced by lowering the period of boiling. Currently researchers are experimenting with a plate evaporator which would appreciably reduce boiling time and minimise the inversion loss.

(iii) Losses in Molasses. The sugar content of molasses obtained from the VPS process is 35% while the sugar content of molasses from the OPS process is as much as 56%. The loss of sugar in the residual molasses is equivalent to a recovery rate of 0.5% - 0.7%. The Appropriate Technology Development Association is working on the extraction of sugar from molasses by an ion-exchange process. The sugar thus obtained is basically wet sugar, which can be used by bakeries and sweet meat sellers.

In the analysis that follows the recovery rate assumed for OPS units is 6.8%, which is the average realised at present. However, calculations have also been made with a higher recovery rate of 7.5% which can be achieved if some of the improvements described above are effected. The recovery rate for VPS units is assumed to be 9.4% which is the current level in U.P.

## 4. The Economics of the Two Techniques

In this Section a comparison of the economics of the two technologies in sugar industry - the Open Pan Sulphitation(OPS) and the Vacuum Pan Sulphitation (VPS) processes - has been attempted. The data for this analysis has been drawn from two agencies - the Planning Research and Action Institute (PRAI) - Lucknow and the Industrial Finance Corporation of India. The PRAI has provided estimates of the capital and operating costs of an OPS unit with a daily cane crushing capacity of 80 tonnes. The IFCI's estimates relate to a VPS unit (capacity 1250 tonnes) to be established in Uttar Pradesh.

Most of the OPS units in India (as many as 90%) are situated in U.P. The PRAI's estimates relate to the operation of a unit in U.P. Therefore, the analysis is in effect a comparison of the technologies in the Uttar Pradesh setting. Average recovery rates (of VPS units) in Maharashtra are 11% as compared to 9.4% in Uttar Pradesh. (The average recovery rate of OPS units in India is about 6.8%). The higher recovery rate in Maharashtra is a result of the higher sugar content of cane. Hence it would be reasonable to assume that if OPS units are located in Maharashtra, their recovery rates would be proportionately higher and the differentials between the OPS and VPS technology would remain the same. Therefore, the comparison presented here should have general validity.

The basic data on capital and operating costs are presented

in Annexure I. Certain important ratios computed with this data are summarised below:

TABLE 5

ECONOMIC CHARACTERISTICS OF DIFFERENT TECHNIQUES

| Ratio | Unit | OPS Technology (6.6% Recovery) | OPS Technology (7.5% Recovery) | VPS Technology (9.1% Recovery) |
|---|---|---|---|---|
| 1. Fixed Capital/ Output | Rupees/ Tonne | 2216 | 2037 | 4349 |
| 2. Fixed Capital/ Employment | Rupees/ Manday | 62 | 52 | 435 |
| 3. Employment/ Output | Mandays/ Tonne | 43 | 39 | 10 |
| 4. Material Cost/ Output | Rupees/ Tonne | 2494 | 2255 | 1032 |
| 5. Value Added/ Output | Rupees/ Tonne | 616 | 815 | 1268 |
| 6. Wages and Salaries/ Output | Rupees/ Tonne | 271 | 248 | 154 |
| 7. Wages/Value Added | Per cent | 44 | 29 | 12 |

The OPS technology is clearly more material-intensive and labour-intensive and less capital-intensive than VPS technology. The cost of sugar produced by the two technologies can be measured and compared either with identical input prices or with the differential prices actually paid by units using the technology. For the case in which identical factor input prices are used, this paper assumes (i) Rs.5 per manday for labour, (ii) 16% interest charges on fixed and working capital, (iii) depreciation at 4% for buildings, and 10% for plant and machinery, and (iv) cane purchase tax at Rs.6.25/tonne. For the second case all costs are actually paid costs.

TABLE 6

COST OF SUGAR PRODUCTION BY DIFFERENT TECHNIQUES AT 1976-77 PRICES FOR NEW UNITS

| | OPS-Technology | | VPS Technology |
|---|---|---|---|
| | 6.6% Recovery | 7.5% Recovery | 9.1% Recovery |
| | Rupees/Tonne | | |
| 1. At Identical Input Prices | 3398 | 3080 | 3097 |
| 2. At Different Input Prices | 3398 | 3080 | 3254 |

Note : A preference adjustment of Rs.700/tonne should be added to the cost of OPS sugar on account of the superior quality of VPS sugar as reflected in the higher wholesale prices, the difference ranging from Rs.700 to Rs.1300 per tonne (Table 4)

If a decision on the allocation of capacity is to be taken entirely on the basis of cost-effectiveness then the optimal decision would necessarily be the allocation of the whole capacity to the single least-cost technique. But a multiple objective approach would take into account objectives other than cost minimisation e.g. employment generation and economy in the use of capital. In such an approach one would minimise costs subject to appropriate constraints.

Several exercises were undertaken with combinations of constraints described below. The objective is to minimise total actual costs (inclusive of preference adjustment in the cost of OPS sugar) as reported in Table 6. The following constraints were used.

A. Output. This must increase from 60 lakh tonnes to 76.3 lakh tonnes between 1976-77 and 1982-83. The output target for 1982-83 is the PPD output target for sugar plus a target for khandsari calculated by applying the PPD growth rate of 2.0% to the estimated base level production of khandsari.

B. Employment. Three alternative employment constraints were tried.

($l_1$) : Employment must increase at the same rate as output.

($L_2$) : Employment must increase at a rate 1.5 times the rate of increase in output.

($L_3$) : Employment must increase at a rate two-thirds of the rate of increase in output.

C. Fixed Capital. Three alternative constraints on capital use were tried. Fixed capital requirements must be :

($K_1$) : Less than or equal to the average of the requirements for each technique separately.

($K_2$) : Less than or equal to the total requirements of a 3:1 distribution of output between the VPS and OPS sectors or

($K_3$) : Less than or equal to the capital requirements of a 1:3 distribution of output between the VPS and OPS sectors.

Combining the above capital and employment constraints nine exercises were undertaken. The resulting share of the OPS technology in total additional output in each of the nine exercises is given in Table 7.

TABLE 7

OPTIMAL SHARE OF THE OPS SECTOR IN ADDITIONAL OUTPUT

| Employment Constraint / Capital Constraint | $L_1$ (248 LM) | $L_2$ (371 LM) | $L_3$ (212 LM) |
|---|---|---|---|
| $K_1$ (53741 LR) | 50% | 50% | 50% |
| $K_2$ (62319 LR) | 25% | 38% | 25% |
| $K_3$ (45180 LR) | 75% | 75% | 78% |

LM : Lakh Mandays. LR : Lakh Rupees

The solutions given above are dominated by the capital constraint except in the case where the capital constraint is liberal ($K_2$). In the case ($K_2L_2$) where the capital constraint is liberal and the employment constraint is tight the shares of VPS and OPS sectors in additional output turn out to be roughly 62% and 38% respectively. This solution would imply the magnitudes shown in Table 8. The rate of growth of sugar production would be 4.1% per annum relative to 1976-77. The rate of growth of VPS output would be 3.2% per annum and that of khandsari output 7.3%

per annum. The actual rate of growth of production in VPS units has been around 3.0% per annum between 1965-66 and 1975-76.

TABLE 8

SECTOR MAGNITUDES IN SOLUTION-$K_2L_2$

| | OPS Sector | VPS Sector | Total Industry | Quantities with Entire Additional Output Produced by VPS Sector |
|---|---|---|---|---|
| 1. Additional Output (Lakh tonnes) | 6.30 | 10.00 | 16.30 | 16.30 |
| 2. Additional Number of Units | 1158 | 66 | 1224 | 107 |
| 3. Additional Employment | | | | |
| - Lakh Mandays | 270.90 | 100.00 | 370.90 | 163 |
| - Permanent (Numbers) | 10,142 | 17,160 | 27,582 | 27,820 |
| - Seasonal (Numbers) | 221,178 | 30,360 | 251,538 | 49,220 |
| 4. Cane Requirements (Lakh Tonnes) | 92.65 | 106.38 | 199.03 | 173.40 |
| 5. Capital Requirements (Rs. crores) | 141.50 | 434.90 | 576.40 | 708.89 |
| 6. Operating Costs (Including Preference Adjustment) (Rs. crores) | 259.17 | 325.40 | 583.57 | 530.40 |

## 5. Government Policy

At present there is no reservation of production for OPS khandsari units. However, OPS units unlike the VPS units, do not have to supply levy sugar. 65% of the output of VPS units is supplied as levy sugar and 35% is sold as free sale sugar. The ex-factory price received for levy sugar is only about 60% of the price received for free sale sugar.

There is also an excise duty differential between OPS and VPS units, the relevant rates being as follows :

VPS units: 27.5% on free sale sugar, (reduced from 45% in November 1977)

12.5% on levy sugar (reduced from 15% in November 1977.)

OPS units: 10.0% (reduced from 17.5% in February 1978)

The effect of the levy and excise policies can be studied with the following calculations. The production cost of VPS sugar in new mills has been estimated as Rs.3,254 per tonne. Assuming that a weighted average realisation of this cost is assured by policy, the excise burden per tonne would be Rs.578. This burden is calculated assuming that the 27.5 per cent excise duty rate is applied to 35 per cent of free sale output, and 12.5 per cent excise rate is applied to 65 per cent levy sugar output - the weighted average incidence of excise being 17.75 per cent. Thus, inclusive of the excise duty the ex-factory price for VPS mill sugar should be Rs.3832.

Similar calculations for khandsari sugar yield the ex-factory price, inclusive of excise taxation, to be Rs.3738 per tonne (production cost Rs.3398 plus excise Rs.340).

Thus, as a result of the levy-cum-excise policy, the production cost advantage of Rs.144 per tonne enjoyed by VPS sugar is converted into an ex-factory price differential of Rs.94 per tonne in favour of khandsari sugar. The latter does not need any extra tax protection.

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ANNEXURE I

PARAMETERS OF ALTERNATIVE TECHNOLOGIES

| | QRS Technology (6.8% Recovery) | QRS Technology (7.5% Recovery) | VRS Technology (9.4% Recovery) |
|---|---|---|---|
| 1. Crushing Capacity (Tonnes/Day) | 80 | 80 | 1250 |
| 2. Crushing Season (No. of Days) | 100 | 100 | 130 |
| 3. Sugar Output (Tonnes per year) | 544 | 600 | 14382 |
| 4. Employment | | | |
| i) Permanent (Nos.) | 9 | 9 | 280 |
| ii) Seasonal (Nos.) | 191 | 191 | 480 |
| 5. Fixed Capital Cost (Rs. Lakhs) | | | |
| i) Land | 4.61 | 4.61 | 14.00 |
| ii) Building | | | 78.98 |
| iii) Plant and Machinery | 4.41 | 4.41 | 399.56 |
| iv) Miscellaneous Fixed Assets | 0.25 | 0.25 | 44.21 |
| v) Stores and Spares | 0.85 | 0.85 | 5.00 |
| vi) Contingencies | | | 15.00 |
| vii) Others | 2.10 | 2.10 | 68.70 |
| Total | 12.22 | 12.22 | 625.46 |
| 6. Costs (Per Tonne of Sugar) (In Rs. at 1976-77 Prices) | | | |
| i) Cane | 2059 | 1867 | 1543 |
| ii) Purchase Tax on Cane | 91 | 83 | 106 |
| iii) Wages and Salaries | 271 | 246 | 154 |
| iv) Consumable Stores and Utilities | 266 | 241 | 152 |
| v) Other Costs | 134 | 122 | 111 |
| vi) Depreciation | 180 | 163 | 435 |
| vii) Interest on Working Capital | 37 | 33 | 58 |
| viii) Interest on Fixed Capital | 359 | 325 | 696 |
| Total | 3398 | 3080 | 3254 |
| Quality Adjustment | 700 | 700 | - |
| Total | 4098 | 3780 | 3254 |

Notes to Annexure I

1. The estimates for the OPS and VPS technology have been provided by the Planning Research and Action Institute, Lucknow and the Industrial Finance Corporation of India, respectively.

2. Crushing Season. The number of crushing season days for the OPS technology is the average reported for 1975/76 and 1976/77. For the VPS technology it is the average for Uttar Pradesh.

3. Output. The recovery rate of 6.8% for the OPS technology is the observed average. A rate of 7.5% is achievable with improvements. The recovery rate for VPS is the reported average for U.P.

4. Employment. These are estimates reported by PRAI.

5. Capital Cost. The capital cost estimates for an OPS unit have been provided by PRAI. For the VPS technology, the capital cost estimates given by the IFCI relate to 2 units (with a capacity of 1250 tonnes crushed per day each): Rs.750 lakhs and Rs.625.46 lakhs. The former appears appreciably on the higher side; hence the latter has been used.

Estimates for 2 units in Maharashtra with the same capacity are much lower at Rs.585 lakhs. The recovery rate in Maharashtra is also higher (about 11.2%). Thus the capital cost per unit of output and capital cost per mandays would both be lower in Maharashtra.

6. The cost of cane has been taken to be Rs.140/tonne and Rs.145/tonne for the OPS and VPS units respectively. Almost the entire cane requirements of the OPS units are delivered at the gate of the factory while the VPS units incur harvesting and transportation charges for a part of the cane purchased. The higher cane cost reflects these additional charges.

7. Wage rates for unskilled labour are about Rs.5/day and Rs.10/day in the OPS and VPS factories. The VPS factories also have to pay retainer fees ranging between 25%-50% of crushing season wages during the non-crushing season.

8. Depreciation rates assumed are: 3% for buildings and 10% for plant and machinery for both techniques.

9. The purchase tax on cane is Rs.10/tonne for the VPS mills and Rs.6.25/tonne for the OPS mills.

10. The same interest rate on working capital (16%) has been used for both techniques. But it is applied to (i) one month's raw material requirements for the OPS units and (ii) 2 months' requirements for the VPS mills.

11. The same interest rate on fixed capital (18%) has also been assumed for the OPS and VPS units.

12. The value of output has been taken to be Rs. 3100/tonne for all units. The assumption is that both OPS and VPS units sell 100% of their output in the free market. In actual practice the OPS factories are not subject to any levy while the free sale of the VPS mills is only 35%. However, the assumption of a common price is used only in the computation of ratios and does not affect the cost analysis directly.

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ANNEXURE II

PROGRAMMING SPECIFICATIONS

The programming model has been specified as a cost minimisation model with constraints on employment generation, output growth and capital requirements.

I. The Objective Function

The objective is to minimise the actual total cost per tonne (at different input prices) as reported in Table 6 inclusive of a consumer preference adjustment of Rs.700 per tonne in the OPS sugar cost. Thus we minimise $325x_1 + 409x_2$ (assuming a 6.8% recovery rate for OPS units), where $x_1$ represents the additional output of the VPS sector in lakh tonnes and $x_2$ represents the additional output of the OPS sector in lakh tonnes.

II. Constraints

A. Output

The demand for VPS sugar in 1982/83 has been estimated as 65 lakh tonnes. The ratio of the output of OPS units and VPS units in 1976/77 was 1:4. Using this rate, output in 1982/83 will have to be about 76.3 lakh tonnes representing an increase of about 16.3 lakh tonnes between 1977/83. Thus :

$$x_1 + x_2 \geq 16.3$$

B. Employment

The output of the two sectors in 1976/77 was 48.00 lakh tonnes (VPS) and 12 lakh tonnes (OPS). Using the mandays/tonne coefficients given in Table 5, total employment would have been

911 lakh mandays in 1976/77. The three alternative employment constraints would then be :

$$(L_1) \quad 10x_1 + 43x_2 \geq 348$$

$$(L_2) \quad 10x_1 + 43x_2 = 371$$

$$(L_3) \quad 10x_1 + 43x_2 \leq 212$$

C. Capital

The fixed capital costs/tonne of sugar as given in Table 5 are Rs.2246 (OPS with 6.8% recovery) and Rs.4349 (VPS). Assuming that capital availability is the mean of the requirement of capital when the additional output is produced either wholly in the OPS or wholly in the VPS sectors, it would be:

$$(K_1) \quad 4349x_1 + 2246x_2 \leq 53741$$

The two alternative constraints would be:

$$(K_2) \quad 4349x_1 + 2246x_2 \leq 62319$$

$$(K_3) \quad 4349x_1 + 2246x_2 \leq 45180$$

ANNEXURE XII

SUGARCANE ACREAGE & PRODUCTION (REGIONWISE)

| | Area (Hectares) (1970-71) | Output ('000 Tonnes) (1970-71) | Unemployment (Person-days seeking and available) Rural (Percentage) | Urban |
|---|---|---|---|---|
| I. ANDHRA PRADESH | | | | |
| 1. Coastal Region | 78966 | 710.426 | 12.79 | 13.60 |
| 2. Inland Northern Region | 22733 | 183.053 | 10.45 | 14.04 |
| 3. Inland Southern Region | 60215 | 152.838 | 11.51 | 9.09 |
| II. ASSAM | | | | |
| 1. Plain | 30406 | 114.548 | 1.97 | 4.26 |
| 2. Hills | 3023 | 10.183 | 0.99 | 0.90 |
| III. BIHAR | | | | |
| 1. Southern | 6090 | 17.940 | 8.20 | 11.19 |
| 2. Northern | 78706 | 281.716 | 9.46 | 6.04 |
| 3. Central | 31488 | 94.429 | 13.55 | 10.57 |
| IV. GUJARAT | | | | |
| 1. Eastern | 136 | 0.993 | 7.67 | 8.07 |
| 2. Northern Plains | 1934 | 7.451 | 5.50 | 6.80 |
| 3. Southern Plains | 6625 | 41.606 | 4.55 | 5.78 |
| 4. Dry Areas | 1819 | 7.882 | 5.93 | 8.23 |
| 5. Saurashtra | 24223 | 112.152 | 2.90 | 7.80 |
| V. HARYANA | | | | |
| 1. Eastern | 103666 | 464.332 | 3.05 | 8.01 |
| 2. Western | 27833 | 126.332 | 2.72 | 7.31 |
| VI. HIMACHAL PRADESH | 3230 | 4.316 | 0.19 | 3.80 |

| | Area (Hectares) (1970-71) | Output ('000 Tonnes) (1970-71) | Unemployment (Person-days Seeking and Available) | |
|---|---|---|---|---|
| | | | Rural | Urban |
| | | | (Percentage) | |
| VII. JAMMU & KASHMIR | | | | |
| 1. Mountainous | 1796 | 1.977 | 1.00 | 6.04 |
| 2. Outer Hills | - | - | 1.01 | 3.73 |
| 3. Jhelum Valley | - | - | 16.81 | 6.74 |
| VIII. KERALA | | | | |
| 1. Northern | 1283 | 9.287 | 21.89 | 22.55 |
| 2. Southern | 6381 | 29.832 | 24.97 | 23.16 |
| IX. MADHYA PRADESH | | | | |
| 1. Eastern | 3865 | 9.465 | 2.12 | 3.42 |
| 2. Inland Eastern | 3237 | 7.465 | 3.23 | 7.00 |
| 3. Inland Western | 13198 | 33.564 | 4.05 | 7.83 |
| 4. Western | 18097 | 44.331 | 6.26 | 8.49 |
| 5. Northern | 14076 | 60.608 | 1.98 | 3.79 |
| X. Maharashtra | | | | |
| 1. Coastal | 466 | 3.486 | 6.93 | 9.10 |
| 2. Inland Western | 145130 | 1094.532 | 8.96 | 9.94 |
| 3. Inland Northern | 17833 | 155.565 | 10.90 | 13.78 |
| 4. Inland Central | 22865 | 135.186 | 7.13 | 8.91 |
| 5. Inland Eastern | 800 | 4.832 | 11.53 | 12.05 |
| 6. Eastern | 6173 | 35.807 | 14.66 | 13.45 |
| XI. KARNATAKA | | | | |
| 1. Coastal & Ghats | 3482 | 31.863 | 5.23 | 8.27 |
| 2. Inland Eastern | 7349 | 66.019 | 5.60 | 11.16 |
| 3. Inland Southern | 32625 | 295.676 | 8.08 | 9.98 |
| 4. Inland Northern | 59100 | 464.911 | 11.03 | 10.11 |
| XII. NAGALAND | - | - | 2.77 | 2.48 |

| | Area (Hectares) (1970-71 | Output ('000 Tonnes) (1970-71) | Unemployment (Person days Seeking and Available Rural | Urban |
|---|---|---|---|---|
| | | | (Percentage) | |
| XIII. ORISSA | | | | |
| 1. Coastal | 12324 | 77.676 | 17.07 | 10.37 |
| 2. Southern | 8191 | 48.041 | 5.28 | 3.92 |
| 3. Northern | 9991 | 57.788 | 10.72 | 8.65 |
| XIV. PUNJAB | | | | |
| 1. Northern | 70811 | 298.002 | 6.25 | 4.89 |
| 2. Southern | 41091 | 178.665 | 2.02 | 7.07 |
| XV. RAJASTHAN | | | | |
| 1. Western | 101 | 0.432 | 5.05 | 5.83 |
| 2. North . Eastern | 16408 | 58.109 | 3.21 | 5.49 |
| 3. Southern | 6729 | 27.050 | 1.10 | 2.00 |
| 4. South Eastern | 9637 | 39.917 | 1.32 | 3.82 |
| XVI. TAMIL NADU | | | | |
| 1. Coastal Northern | 49732 | 425.449 | 14.59 | 13.22 |
| 2. Coastal Southern | 24699 | 198.023 | 8.37 | 10.09 |
| 3. Inland | 48502 | 417.571 | 8.51 | 10.52 |
| XVII. UTTAR PRADESH | | | | |
| 1. Himalayan | 119558 | 537.808 | 1.18 | 8.15 |
| 2. Western | 670450 | 2888.585 | 2.76 | 3.22 |
| 3. Central | 189525 | 699.902 | 2.38 | 4.38 |
| 4. Eastern | 324036 | 1224.014 | 4.56 | 3.56 |
| 5. Southern | 5550 | 13.266 | 3.28 | 5.07 |
| XVIII. WEST BENGAL | | | | |
| 1. Himalayan | 986 | 4.268 | 7.80 | 6.79 |
| 2. Eastern Plains | 22877 | 119.389 | 11.37 | 15.65 |
| 3. Western | 6459 | 32.178 | 14.42 | 7.02 |
| 4. Central Plains | 6518 | 37.737 | 9.63 | 11.13 |
| All India | 2481319 | 12340.636 | | |

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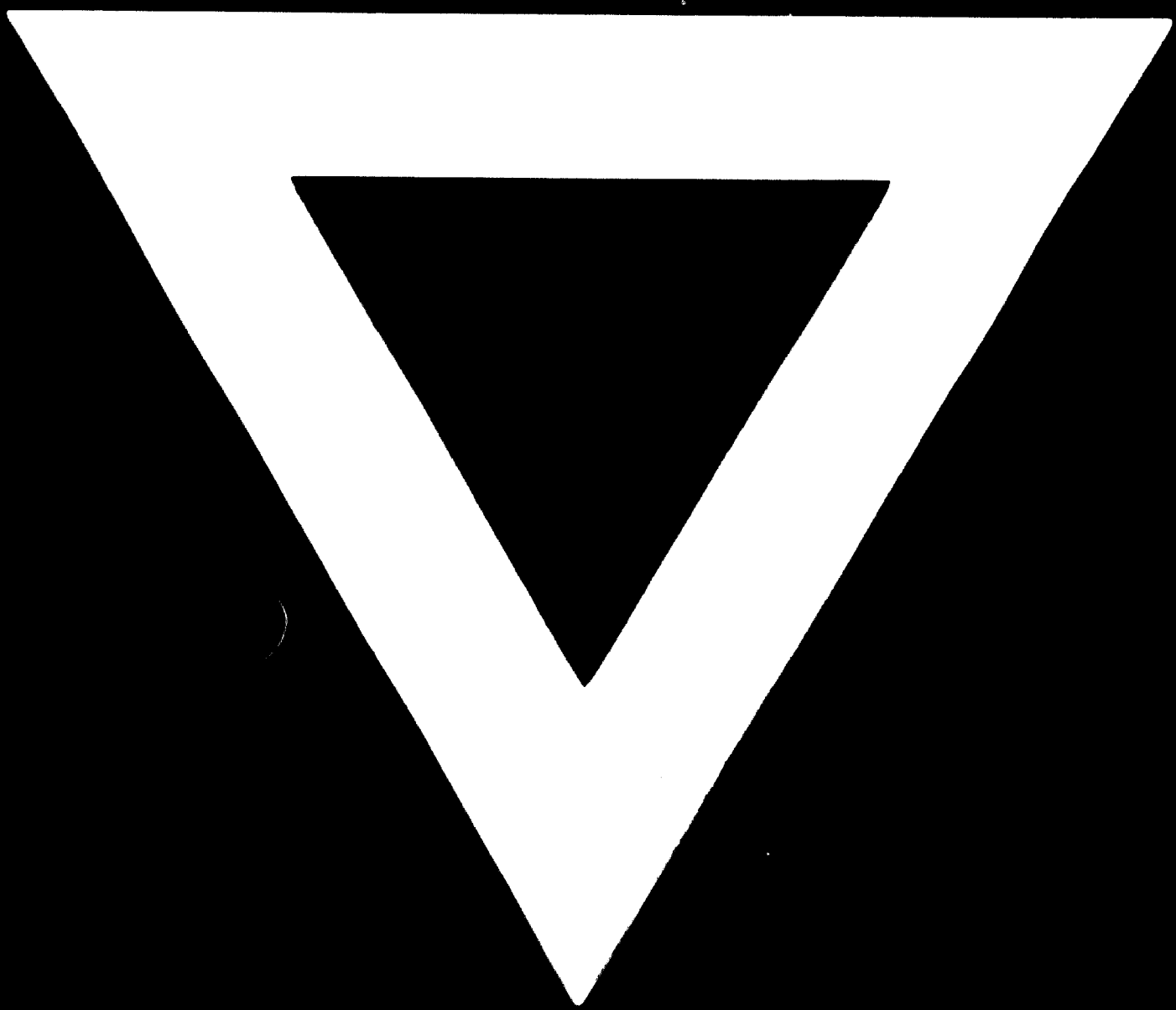

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