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Energy Monitoring Study

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British Steel Consultants Limited

British Steel Consultants

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MEASURES FOR

ENERGY SAVING AND CONSERVATION

IN

SAIL'S STEEL PLANTS IN INDIA

ENERGY MONITORING STUDY

UNIDO Contract No. 86/10

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MEASURES FOR
ENERGY SAVING AND CONSERVATION
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SAIL'S STEEL PLANTS IN INDIA

ENERGY MONITORING

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PART 1

ENERGY MONITORING STUDY

GENERAL REVIEW

GENERAL REVIEW

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1.0 INTRODUCTION

British Steel Consultants (BSCOS) were awarded a contract by UNIDO with the object of improving energy conservation at three SAIL plants viz. Bhilai, Rourkela and Bokaro.

This was to be achieved by:

a) bringing awareness and commitment in SAIL plants for the need to conserve energy and hence reduce production costs.

b) transferring know how in techniques of energy conservation from British Steel's own experience to SAIL.

c) training SAIL engineers in the techniques of energy conservation

The work was divided into a four phase programme as shown in our technical submission No. UND/IND/85/064

1.1 General Energy Management

As a first part of this programme a visit by British Steel energy experts was made in March 1987 to the three integrated works to identify principal areas of action, spending two weeks in each plant. Technical support was provided to SAIL in two broad categories:-

A. Technical Management: where energy savings were identified through:-

a) better understanding of operating practices.

b) alteration of operating procedures, if necessary

c) reduction of energy consumption through improved operation.

d) reduction of energy losses.

e) improved maintenance and good housekeeping.

B <u>Organisational Management:</u>

a) establishing an effective energy management structure.

b) establishing an effective energy policy.

c) ensuring adequate reporting sys em

d) creating awareness and influencing attitudes of the workforce.

e) communication and motivation.

The specific energy consumption of each plant was assessed on a process basis and compared against the IISI proposals, BSC practice and against each other. Areas of energy savings were identified and a specific action plan was recommended. A draft report was prepared and issued in August 1987.

It was recognised that to achieve energy savings, plant management commitment was essential. Therefore, in October 1987 the report was discussed in detail with the SAIL senior management team during their visit to the UK, and a priority implementation programme was agreed.

It was also agreed:-

(i) to constitute a standing committee on energy conservation at Corporate level with the Director - Operations as Chairman. The committee would meet every three months to formulate policy and monitor progress.

ii) to constitute Energy Conservation Committees at plant level with the Executive Director as chairman to assess the plant performance. These committees should meet at least once a month.

1.2 Energy Audit

In order to implement an energy management programme it is essential to understand each process area and its effect on integrated steelworks in detail through energy auditing techniques.

Since more than 50% of the total energy in a steelworks is consumed in ironmaking, SAIL are anxious to improve the performance of their sinter plants. From the earlier report it was established that SAIL plants, on average, consume twice as much energy as the best BSC practices.

Generally service areas are taken for granted. Effective generation, distribution and utilisation of steam and power can often offer substantial energy savings at little or no cost for a steelworks. In SAIL it is doubly important because of a heavy reliability on State grid supply which is not very dependable. Therefore, during the SAIL senior management team visit the two priority areas highlighted for audit work were:-

a) Sinter Plant
b) Production, Distribution and Utilisation of Steam and Power.

Consequently a visit by BSC experts was made in March 1988 to the three integrated steelplants to carry out detailed auditing in the priority areas agreed and develop conservation schemes. Three weeks were spent in each of the plants.

At the completion of this study a report was submitted highlighting energy conservation schemes and the potential savings, with priorities determined by capital cost and capital pay back periods.

Recommendations were also made to SAIL outlining specifications for energy monitoring equipment to conduct detailed energy audits.

The recommendations of this report were again agreed with SAIL Senior Managers who visited the UK in September 1989 and a follow-up action plan was drawn.

1.3 Training

In order to provide assistance to SAIL engineers in implementing the recommendations made in the General and Energy Audit reports, training to forty SAIL engineers was given in five batches of eight trainees and each lasting six weeks during the year 1988/89. The training comprised classroom and works experience in the UK.

The objectives of the training courses were to enable the trainees to:-

a) understand the overall utilisation of energy in an integrated steelplant.
b) assess the energy needs of processes in an integrated steelplant.
c) learn the methodology of energy audits.
d) obtain practice in conducting energy audits in integrated steelworks, to draw conclusions and make recommendations on their basis.
e) appreciate modern techniques of energy saving in steelplants and modern equipment dedicated to saving energy.
f) appreciate the concept of energy management in an integrated steelworks.
g) prepare techno-economic studies for energy conservation schemes.

The training courses were monitored and reviewed to meet the demand of the participants. A review of courses was presented in a report in October, 1988.

1.4 Monitoring and Targeting

It is not enough to study and develop energy saving schemes and to agree to a programme of implementation. It is as important to note that the implementation programme has progressed and the predicted savings are being achieved. This helps management to keep an overall control of operation and set new targets.

The final visit, between the dates of 5th March and 25 March 1990 was made by Dr S P Hansrani (Project Manager) and Mr S H Brocks (BS Consultant) to assesses the progress made in the three years since the first visit. In more detail the objects were (a) to quantify and analyse the changes in energy consumption (b) to determine the reasons for improvements or deterioration in such performance, and (c) to investigate the progress made in implementing the recommendations made in 1987 and 1989.

The data is presented in this report for each of the three SAIL plants studied.

2.0 SUMMARY DISCUSSIONS

The visits were of short duration (4 days at each plant) as it was not the intention to carry out a new updated survey but to monitor performance. Therefore it was not possible to check data and opinions expressed by SAIL personnel in detail. Indeed little time could be spent on plant and the method used was to assemble the data, and from this to formulate questions for interviews with energy departments and production/personnel.

2.1 Energy Management

Although there was not enough time to study this aspect in detail it was clear that the new committee structure was more effective than the one it replaced. Having the Corporate Director Operations in overall charge and the Executive Directors chairing the plant level meetings had given the energy campaign greater impetus.

Energy departments were clearly receiving more support and seemed to have greater authority. The improvement was not uniform, depending no doubt on the personnel involved. Some of the suggestions for changed departmental structure had not been implemented. The reasons were not sought but it should be ensured that the proposals have been considered.

The reporting system (the IISI method of presentation) that had been introduced for the year 86/87 was praised in the first report and it has been maintained and improved somewhat and R and D now collect the data and circulate across the whole corporation. BSP is still the only plant where the process is computerised although other plants intend to do the same.

Three years ago the main criticism was the lack of uniformity from works to works particularly in some sections. Detailed suggestions were made to rectify this situation in the general 'Energy Conservation Study Report (Vol. 1, p. 26, section 8.5.3). Little or nothing appears to have been done. The new feature revealed on the current visit was that the energy in oxygen is not only different from plant to plant but that it varies at Bokaro month by month. This could be tackled by adopting a corporate standard factor which is fixed (as is done for electricity). Unfortunately any excess usage of energy for oxygen production would finish up in "Miscellaneous and Losses". Such variances should be highlighted and not hidden. There are other ways of tackling this but a method that is the same at all works is desirable. It is suggested that R and D could resolve this and the previous proposals.

On the question of energy awareness, it is dangerous to rely on impressions gathered on such a short visit. There is no doubt that publicity has improved considerably but it is difficult to assess the effect on attitudes. The general impression is that there has been a marked improvement in awareness especially in the higher levels of management but transfer into action is still slow.

It was hoped that the experience gained by trainees in the UK will be used to set up task forces in each works to bring about attitude changes to working practices and to implement priority energy saving schemes in the works. This has not been pursued. Furthermore there is little inter-action between the works technical people on a regular basis. It is recommended that R&D should take an active role in promoting such interchange.

2.2 Process Areas

The basis of the comparisons in this report was the IISI method of presentation which is produced by all the works on a monthly and annual basis. Figures for the year April to March 86/87, 87/88, 88/89 and April 89 to February 90 (11 months) are tabulated for all departments with the main comparison being drawn between 86/87 (the year before the first visit, and 89/90, the 11 months of the current financial year).

Although the details of each process area are to be found in the following sections devoted to each separate works, it is the intention here to summarise the results on a process basis referring in particular to similarities and differences between works.

2.2.1 Coke Ovens

All the works showed improvements, from 6% at BSP to 25% at RSP and nearly 30% at Bokaro. The latter plant is now within striking distance of "Best World Practice". All showed significant improvements in "energy yield loss" (particularly at BSL) and this factor was the main explanation of the overall savings made. At BSP and RSP gas and by-product yield improvements contributed, but at BSL (and to a lesser extent at RSP) the enormous savings were due to better coke yield. It was difficult to pinpoint this achievement and disappointing that the proposed investigation of weighing, analysing, and accounting for coal and coke did not appear to have taken place.

All plant have improved door and frame cleaning equipment and at some better charging practices are being introduced. There was at least partial failure to implement the proposals to reduce screening losses. BSP had made a useful reduction from 17.5% to 15%. RSP had reduced from 26% to 22% but had not gone far in reducing the size of the coke oven breeze screens. At BSL the screenings had risen from 20% to 25%, with no apparent changes in practice except improved blast furnace coke screens. The range of this value (15-25%) is very large and all plants should be able to emulate Bhilai with significant potential energy savings due to the lower coke/steel ratio.

2.2.2 Sinter Plants

The improvements were generally spectacular and at least partly due to large output increases (RSP - 24%, BSP - 35%, BSL - 11%). At Bokaro where the output increase was limited it had been achieved by two strand operation for much of the time. The credit must go to better attention to detail.

Coke breeze savings were the most important and return sinter had been reduced by 3-8%. The coke economies are due to higher output, better breeze crushing, higher suctions, increased bed height etc. Only BSP have not increased bed height and only RSP have progressed to a fully rational screening system. At the other two works +6mm sinter is being returned to the plant.

Whilst Ignition gas has been reduced per ton of product, the levels are still high. It is suggested that the proposals made in the Audit Report of 1988 should be adopted.

2.2.3 Blast Furnaces

All plants have made savings but they have not been dramatic in percentage terms (0.5% at BSP, 2.5% at RSP, and 5.1% at BSL). As the blast furnace is a large user of energy these small percentages represent useful plant savings at least at the latter two plants.

All works have shown coke savings with the 6.6% reduction at RSP being the most creditable. In all cases a reduction of gas recovery has automatically offset much of the energy saving (75% at RSP and 35% at BSL). Nevertheless the coke rate reduction will enable coke oven plant production ratios to fall and so save energy overall. Only Bokaro shows an improvement in stove gas consumption and even there the lower coke rate and lower blast temperatures must take the credit, rather than an improvement in stove efficiency. At Bhilai the higher blast temperature accounts for only half the 9% deterioration. Similarly at Rourkela the increase of 4% was achieved despite lower coke rate and lower blast temperature. Hence the stove efficiency at these two plants has worsened from what was an unsatisfactory base. This area requires priority attention. The other area of excessive energy usage was steam for blowing. All plants have made savings due to the implementatgion of at least some of the suggestions made three years ago. Savings range from 4% at RSP to 15% at BSL. Whilst this is encouraging the reductions fall short of the potential outlined in the first report, particularly at RSP where only one seventh was achieved. At the other two plants 35-40% of the potential had been realised. More remains to be done and a detailed survey is called for, particularly at RSP.

2.2.4 Steelmaking

Both the Open Hearth plants have produced very creditable improvements in output (19-23%), with an accompanying reduction in energy usage of about 20%. A major reason is the adoption of the twin hearth system at BSP and of the Korf system at RSP. Data were not readily available to enable separate analysis of the orthodox O.H. practice. It is disappearing in any event as the new techniques are being extended.

The LD plants had behaved differently. At RSP output was down slightly due to hot metal shortage. At BSL output was up 28% and at BSP by a massive 86% as the restrictions on the LD route were removed. Energy at BSP was down by 28% but there was a small increase at BSL (1%) due to higher energy oxygen. The increase of 8% at RSP was blamed on fuel at the lime plant. Most importantly the LD ratio at BSP had improved significantly to 40% of the total steel.

The level of hot metal usage is crucial as lower levels will allow lower blast furnace production ratios (and coke and sinter). There had been modest but useful reductions at BSP and RSP of 13 and 21 kg/ton but it was disappointing to note a large increase of 59 kg/ton at Bokaro. This was said to be due to a large increase in the so-called "Mixer Losses", and is under investigation. It is worth noting that the current levels of hot metal usage range from 969 kg/ton at BSP to 1030 kg/ton at RSP. There could be dramatic energy savings if all the plants could reach the Bhilai level. Indeed Bokaro achieved 936 kg in 87/88. It would appear that Rourkela have the biggest problem as there is also an iron constraint, and the proposals made three years ago (ladle turn round, insulation, ladle lids etc) should be acted upon.

The failure to utilise LD gas at BSP and BSL must be criticised. Only recently has a part of the gas at Bokaro been put to use.

2.2.5 Continuous Casting

The caster at Bhilai is now operating at near design capacity. The important energy consideration is that the C.C. ratio has increased from 32 to 46% of the semis so that a bigger proportion of the steel is via the more energy efficient process route.

2.2.6 Primary Mills

All three primary mills gave good results. Outputs were increased by 9% (RSP) to 35% (BSL). Energy savings ranged from 8% at RSP to a very creditable 33% at BSP. In all cases fuel savings were the main factor. At Rourkela and Bokaro the production ratios increased - perhaps due to better yields so that the energy savings per ton of crude steel were not as great. At Bhilai, because of increased continuous casting the production ratio reduced so that energy per ton crude steel was 41% less. Operations have improved as evidenced by the lower cold charging at BSP ard BSL, by 3% and 7% respectively. Also track times have come down at all works, although only marginally at Bokaro where they tend to be significantly longer than at the other works.

Improvements have been effected by the fitting of microprocessor controls and structural modifications to lids, seals etc. The number of pits in use however has not been reduced at any of the plants, and although the penalty for excess capacity will not be as great at the current higher outputs, there is still scope for reductions and further energy savings.

2.2.7 Secondary Hot Mills

As these differ from plant to plant it is not easy to make generalisations so brief comments will be made on a works basis.

2.2.7.1. Bhilai

All four mills (Rail, Merchant, Rod, and Plate) have had significant increases in throughput, particularly the Rail and Plate mills (17% and 56%). All have reduced energy usage. From 6% at the Rod mill to 27% at the Rail mill and 36% at the Plate Mill. At all but the Plate mill the major reduction is in furnace fuels due to increased output, better skid insulation and the application of better (microprocessor) controls. At the Plate mill, despite the massive output increase and improved skid insulation and controls, the fuel saving is only marginal, and the major contributor is electric power saving. The power usage per ton is less than half the level of three years ago. This is perhaps a special case as two shift operation was practised in 86/87, but economies in the use of power and steam have been made in all the mill areas.

2.2.7.2 Rourkela

The general picture is disappointing. The Plate mill output is down slightly (6%) but energy is up by 22%, mainly due to increased fuel usage. At the Hot Strip mill (HSM) the output has increased by 21% but energy consumption is only down by 1%. There had been a recuperator failure at the Plate mill normaliser, and it was stated that the product mix at the HSM was worse than before. It is planned to install new burners and recuperators on the HSM furnaces, with a forecast fuel saving of 25%.

2.2.7.3 Bokaro

There has been a large increase in production at the HSM of 43% and a very creditable reduction in energy of 18%, mainly due to fuel savings, although power and steam have also contributed. Despite this improvement the total energy is still some 22% higher than the RSP mill and more than double best World practice. The steam recovery from skid cooling was down by 40% which was only partly attributed to improved skid insulation. Hot charging has been introduced and reached a level of 11% in 89/90.

2.2.8 Cold Mills and Specialist Mills

At RSP C.R.M the output was 15% higher but energy 6% worse. There were savings in fuel and power but these were offset by a huge increase in energy for Nitrogen and Synthesis gas. This can partly be due to an additional ASU in operation, but the trend is disturbing.

At Bokaro C.R.M. output was nearly doubled compared to 86/87 and energy was down by 37%, mainly due to a 65% reduction in steam usage, but aided by 31% lower fuel. Overall the BSL mill has overtaken RSP for the lead in this category and is now some 28% better.

Some annealing furnaces have been fitted with ceramic fibre linings, and others will follow.

The specialist mills at RSP were not considered in detail, but the huge increase in power at the Pipe mill, fuel and power at the Electric sheet mill, and fuel at the CRGO mill should be investigated.

2.2.9 Steam Generation and Usage

It is not very rewarding to attempt to compare the efficiency of steam production between the works because, (a) all but Bokaro use a fixed enthalpy per ton of steam - whatever the steam conditions, (b) condensate return is ignored and (c) energy used for steam raising is the small difference between two large numbers. For what it is worth BSL boilers apparently use a little more than half of the energy of the other two plants.

Comments on the changes in steam raising efficiency over the years ought to be valid but the introduction of new plant makes interpretation impossible where boiler plant are not reported separately (all except RSP). Apparently there has been a small deterioration in energy per ton of steam at Bhilai and improvements of 45% at the other works.

The total steam output has increased at all plants but particularly at Rourkela where it is 62% higher. This is shown in Table 1.1 where steam make is also expressed on a crude steel basis. There are interesting differences both with time and between plants. The steam/ton crude steel ranged between 2.35 at BSP to 5.12 at RSP where there has been a 57% increase in this parameter. These changes are the result of commissioning new "Captive" power plants and the different levels reflect to a large extent the proportion of power generated within the plant.

The Process Steam is derived by adding the Waste Heat Steam and taking away the net steam for power production and blast furnace blowing. The table shows this on a crude steel basis and it is encouraging to note substantial reductions of 15% at BSP and 23% and 24% at BSL and RSP respectively. The actual value is lowest at Bhilai and the Bokaro usage appears to be very much higher. At this plant however the air compressors are steam driven and this should have been excluded.

2.2.10 Power Generation

Comparisons of Power generating efficiency are also hindered by the use of artificial steam enthalpy data at BSP and RSP. Apparently Rourkela are most efficient and have made the greatest improvement since 86/87 and BSL is the least efficient and has made only a slight advance. These data may not mean very much but Table 1.1 shows that there have been significant changes at all works with electricity outputs up by 36% at BSP, 248% at RSP and 89% at BSL. The proportion of "Own power generation" has increased at all works but particularly at Rourkela where more is generated than is used on the works.

Power consumption per ton of crude steel is also shown. Reductions of 14% and 18% have been made at BSP and BSL. The usage is still high but the huge increase of 22% at Rourkela, to the very high level of 826 Kwh/TCS is disturbing.

2.2.11 Miscellaneous and Losses

A large amount of energy falls into this category, varying from 5% of the total at RSP to 8% at BSP and BSL. Rourkela is the lowest but has shown a 22% deterioration, mainly due to excess fuel offset by power savings.

At BSP there has been a useful fall of 34%, largely because of lower fuel and oxygen.

Bokaro have the highest value in this category but a saving of 20% has been made since 86/87, due to lower power, fuels and steam.

It is not possible to discriminate between true losses and usage on Auxiliaries and it would be preferable to report the two types of usage separately.

2.3 Summary Comparison

It is of some interest to compare departmental consumption of the three works. Indeed such comparisons are more relevant than overall energy usage because of the different nature of the three works. For example, much of the special steel production i.e. tin plate, electrical steels etc. is carried out at Rourkela and must carry an energy penalty. Table 1.2, shows such comparisons. The BSL coke ovens are clear leaders. The best sinter plant is RSP and Bokaro are the leaders for blast furnaces. the lowest energy for OH furnaces is Bhilai - but the lancing processes at the two works are different. Bhilai also leads the field for LD steel making and Rourkela for primary mills, plate manufacture and hot strip. Bokaro has a much lower cold mill energy usage but it is not really comparable to Rourkela.

Too much significance should not be attached to boiler usage due to differences in the methods of valuing steam. Similarly for power generation.

There is a large spread in the "Miscellaneous and Losses" category with RSP being considerably lower than the others. Perhaps there are differences in the content of this category and this supports the proposal to report the two parts of this classification separately.

BSP are the best plant in the most important category of all, i.e Total Energy Consumption.

These comparisons are stressed to encourage the plants with inferior results to study the leading plants in the various categories to promote interchange of technology and ideas.

Table 1.2. also includes the percentage changes departmentally over the three years under review. This is an important part of the study. It is encouraging to note that all departments at BSP and BSL have improved with the exception of boilers at BSP (always a doubtful statistic) and the LD shop at BSL (only because of high energy oxygen). At RSP savings have been made in all areas down to the Primary mill, but it is disappointing that most of the secondary mills have deteriorated and that "Miscellaneous and Losses" has increased considerably.

However the comparison must take into account the different circumstances and plant configurations. At RSP output has increased by only 3%, whereas at BSL better utilisation of installed capacity has seen output rise by 28% and at BSP a lot of new plant has helped to give 38% increase in output.

Some of the savings are due to changes in the production ratios (P.R) and this has been analysed in parts 2,3 and 4.A summary is presented below;

Gcal/TCS	BSP	RSP	BSL
Savings/(Losses) due to production ratio change	0.445	(1.369)	0.948
Savings/(Losses) due to changes in Department efficiency	1.512	2.384	1.758
Total Savings/(Losses) Actual	1.958	1.015	2.706

These derived figures differ a little from the works data due to differences arising when computing the Total from the departmental records but are sufficiently accurate to demonstrate the effect. RSP shows a deterioration due to changed P.R., whilst the other two works benefit by lower P.R. This is particularly the case at BSL.

A detailed explanation is not attempted, but taking the two extreme cases (BSL and RSP), the former has shown big gains in the coke/iron area which could be due to using stock coke and iron (or not making as much surplus as in 86/87). At RSP the big change is in the steam and power area due to new plant and very high levels of power generation.

This analysis demonstrates that RSP with the lowest overall savings has the best improvement in departmental efficiency. It should not be thought that only departmental efficiency is important, or that changes in production ratio are outside management control. P.R. can be changed to advantage by management action (e.g. Coke screenings; Hot metal usage in steelmaking; Power generating policy etc). But it is also influenced by product demand, import/export of semis etc. But it is important to know which type of saving is being made.

The total economies range from 6.5% (RSP) to 21.4% (BSL). Correcting the data to represent balanced material flow changes, the range is 11.3% (RSP) to 17% (BSP).

Table 1.3 shows what these savings are worth in cash terms.

The average price of the energy mix at each works is taken from the SAIL Budget for 1989/90. As energy economies will often save the more expensive fuels this basis will tend to underestimate the value of the improvements.

Although BSP has the lowest energy usage it also has the highest priced energy so that BSL becomes the plant with lowest energy costs and Bhilai has the highest.

The value of the savings of energy over the last three years varies from 129 Rs/TCS (RSP) to 432 Rs/TCS (BSL). These equate to annual savings ranging from Rs 14.7 Crore (Rs 147 x 10^6) at RSP to Rs 116 Crore (Rs 1160 x 10^6) at BSP. The total for the three works is no less than Rs 244.3 Crore (Rs 2443 x 10^6). This clearly demonstrates the value of the energy campaign and should encourage further efforts.

3.0 Conclusions

With overall savings of 6.5% at Rourkela, 16.7% at Bhilai, and 21.4% at Bokaro the project must be judged a resounding success. The energy economies achieved are equivalent to 130 to 430 Rs/TCS and amount in total to no less than 244 Crore Rupees (Rs 2440 x 10^6).

At balanced flow conditions the saving at RSP would have been 11%, BSP 17% and at BSL the saving would have reduced to 12%. The progress in three years is very satisfactory. The cost in cash, time and effort must be considered to have been well spent.

However it must be recognised that a great deal depends on the much higher outputs achieved and the new plant that has been commissioned. Any fall in output would be catastrophic in energy terms.

It must also be stressed that there is still a long way to go and pressure must be maintained. It would not be unrealistic to aim for similar savings over the next three years, but it will become more difficult.

There must also be some criticism of the fact that a good many of the earlier proposals have not been acted upon. More commonly proposals have been taken up but have tended to be "too little and too late".

There is also an impression that too much emphasis is placed on capital projects and not enough on the cheaper, quicker route of improving operations and maintenance. Nevertheless a very good start has been made towards achieving the full potential.

TABLE 1.1

STEAM AND POWER GENERATION AND USAGE	BSP	RSP	BSL
TOTAL STEAM GENERATED (89/90) kT/Annum Change since 86/87, %	6995.00 +21	5813.00 +62	9227.00 +33
TOTAL STEAM MADE, 89/90 Tons/Ton Crude Steel Change since 86/87, %	2.35 -10.8	5.12 +57.2	3.51 +3.8
PROCESS STEAM, 89/90 Tons/Ton Crude Steel Change since 86/87, %	0.82 -15.0	0.86 -23.7	1.35 -22.6
TOTAL POWER GENERATED, 89/90 Gwh/Annum Change since 86/87, %	575.00 +36	1041.00 +248	1155* +89
POWER CONSUMED, 89/90 kWh/ton Crude Steel Change since 86/87, %	492.00 -13.5	826.00 +21.5	539* -18.3
WORKS GENERATION, % of Works Consumption	38.00	111.00	53*

* FIGURES ARE FOR 88/89

TABLE 1.2

ENERGY SAVINGS COMPARISON FOR BSP,RSP AND BSL (1986/87 - 89/90)	ENERGY CONSUMPTION Gcal/TP (89/90)			SAVINGS/LOSSES MADE SINCE 86/87 - %		
	BSP	RSP	BSL	BSP	RSP	BSL
Coke Ovens	1.941	1.875	1.231	6.000	24.600	29.500
(Coke Oven "Yield Loss")	0.652	0.769	0.299	23.100	40.900	61.600
Sinter Plant	0.681	0.586	0.772	27.600	36.900	12.900
Blast Furnaces	3.758	4.295	3.635	0.500	2.500	5.100
Hearth Furnaces	1.003	1.587	-	20.000	21.100	-
LD Steel	0.449	0.590	0.562	27.500	(8.3)	(1.4)
Continuous Casting	0.166	-	-	16.200	-	-
Primary Mills	0.577	0.404	0.698	32.500	7.800	17.700
Billet Mill (Direct)	0.089	-	-	37.300	-	-
Rail and Struct. Mill	0.932	-	-	26.800	-	-
Merchant Mill	0.929	-	-	7.700	-	-
Rod Mill	0.806	-	-	6.000	-	-
Plate Mill	1.460	1.302	-	35.800	(22.3)	-
Hot Strip Mill	-	0.972	1.186	-	1.200	17.800
Cold Rolling Mill	-	1.788	1.073	-	(5.9)	37.000
Pipe Plant	-	0.474	-	-	(55.4)	-
Electric Sheet	-	5.410	-	-	(18.5)	-
CRGO	-	7.484	-	-	1.400	-
Boilers	0.093	0.099	0.055	(6.9)	46.200	45.000
Power Generation	0.420	-0.084	0.555	38.000	100+	3.800
Miscellaneous & Losses	0.781	0.551	0.843	33.500	(21.6)	20.000
Total Actual Gcal/TCS	9.780	11.397	10.310	16.700	6.500	21.400
Total Balanced Gcal/TCS	8.923	10.330	9.315	17.000	11.300	12.200
Process Steam t/TCS	0.819	0.856	1.346	15.000	23.600	22.600
Electricity kwh/TCS	492.000	826.000	-	13.500	(21.4)	20.000
Yield of Skip Coke/GCoke	0.849	0.779	0.755	-	-	-

TABLE 1.3

ENERGY COST SAVINGS, (1987/88 - 89/90)			
	BSP	RSP	BSL
Output, kTons (89/90)	3082.00	1136.00	2630.00
Energy Saving (c.f. 86/87) Gcal/ton	1.95	0.79	2.81
Total Energy Used, Gcal/ton	9.78	11.40	10.31
Average Energy Price, Rs./Gcal	192.70	163.70	153.95
Value of Actual Energy Savings,Rs/TCS	376.50	129.30	431.80
Monetary Savings/annum, Crore Rs*	116.04	14.69	113.56
Total Energy Cost Rs/ton Crude Steel	1884.60	1865.70	1587.00

* 1 Crore = 10 million

PART 2

ENERGY MONITORING STUDY

BHILAI STEEL PLANT (BSP)

ENERGY MONITORING - BSP

CONTENTS

TABLES

TABLES continued

2.0 ASSESSMENT REPORT ON BHILAI STEELPLANT

2.1 Coke Ovens

Since the first visit a new battery of tall ovens similar to those at Bokaro has been commissioned and this is largely responsible for a 24% increase in output. It was disappointing that the results for this battery could not be separately reported because of by-product plant and coke conveyors being common to the older plant.

However the new battery would be expected to contribute to the overall reduction in stage energy of 6%. Table 2.1 shows the data for the four years studied. Analysis in this and other sections is largely based on a comparison of 86/87 with 89/90.

Underfiring gas consumption is only 2% better then 86/87 and is attributed to the fact that there is now a bigger proportion of the ovens on Blast Furnace gas firing where efficiency is always lower.

The electric power and steam consumption has increased by 38% and 28% respectively. This is believed to be partly due to changes in the methods of allocation which have been refined; but there are other explanations. Firstly the new battery is served by an electric exhauster and an extra electric exhauster has been installed on the older plant so that only one steam driven unit is normally in use. This could explain the increase in power usage. It should be possible for BSP to confirm this. Three years ago steam driven back pressure exhausters were in use but the exhaust steam was being blown to waste due to poor quality input steam. It was recommended that electric drives would be better, but that the proper use of back pressure drives would be better still. So part of the proposals were implemented but the steam conditions are said to be still unsatisfactory so that back pressure operation is not practised.

However these changes should have reduced steam consumption. On-main charging has been introduced on the new battery and on one of the older ones. This necessitates steam jets in the ascension pipes and could go some way towards an explanation. It is encouraging that it is intended to fit the more energy efficient method of liquor aspiration on No.4 battery which is rebuilding.

Gas and by-product yields have improved significantly by 5% and 17% respectively. This is due to (a) the on-main charging practice at some of the batteries, as this gives less gas leakage, (b) improved operation in limiting/eliminating the practice of open ascension pipes (except when charging off-main), (c) improved door sealing. (Hydro jet door cleaners are installed on all ovens and mechanical frame cleaners are in use at batteries 1 and 9 so far), (d) Better brickwork maintenance by refractory spraying and crack welding. A brief visit to the batteries confirmed that conditions were greatly improved, though some smoking chimneys showed that more needs to be done.

The "yield loss" (the difference between the thermal input of coal and the output of coke, gas and by-products) had improved by 23%. It is now 7.3% of the coal input, rather than the 9.5% of three years ago. Whilst the improvement is creditable, the loss is still much too high. Over 70% of this improvement is due to the better gas and by-product yield and this alone more than accounts for the overall energy saving. Energy net of "yield loss" is in fact higher by 6% due to the increased steam usage.

It is disappointing that the suggestion to mount a special exercise to improve weighing and analysis of coal and coke has not been activated. Even the coal tower weighbridge on the new battery does not work (a lever type was installed when load cells would have been better). Load cell weighing on the coke car is being installed on No.9 and is already in existence on some of the older batteries. The coke belt weighers were not working well and the method of accounting still relies on BF skip weights and sample weighing of screenings.

The importance of reducing the screening loss was emphasised three years ago. The bottom size of the coke oven screens has been reduced to 20mm (from 25mm), but despite this, and the increased use of foreign coal, the screenings at the coke ovens have increased marginally. This is said to be due to a tightening up of the top size crushing and screening (80mm).

The screenings at the blast furnaces where screens had been reduced to 20mm also, had improved from 7% to just over 5% so that overall screen loss had reduced from 17.5% to 15% which is the lowest level in the three SAIL plants. This contributes to the lower production ratio (that is the gross coke over crude steel ratio). The net energy usage was 6% improved on a product basis but was 15% better on a crude steel basis.

During the visit BSP management quoted that implementation of just two of BSC recommendations in this area (i.e. improved screening system, and door/frame cleaning) have given a potential saving of Rs 2.45 Crores p.a.

2.2 Sinter Plant

A fourth strand is being constructed at SP2. Output has increased by 35%. Coke breeze, ignition fuel and power usage are all reduced considerably by almost 28%, as is the total usage (see Table 2.2).

Strand utilisation had improved by 12% so specific output was up by something of the order of 20%.

The most important saving is coke breeze which represents over 70% of the total savings. The reason for this was stated to be due to better ignition. It is difficult to accept that this is a major factor. Clearly fewer stoppages, better output and lower return fines must all have contributed and are probably the major factors.

The reduction in stoppages was partly attributed to the new system of delivery of sinter from SP1 to blast furnaces 1, 2 and 3 where there is a new high line screen at 5mm and a large surge bunker.

There has been some improvement in strand suction, accounting for some of the improved sintering speed. No.1 strand had been overhauled and a new stronger fan fitted, and on No.4 machine spring loaded seal bars had been fitted in the wind boxes. No.1 was now achieving a suction of 700mm water gauge and No.4 625mm as compared to the 550mm on SP1 three years ago.

Ignition gas is down by 28% but is still perhaps three times higher than good world practice. Longer, side fired ignition hoods have been installed on SP1 but only one strand had automatic control. On SP2 the 3-zone hoods are now said to be converted to long 2-zone hoods, with the second zone unfired. Whilst the later is a move in the right direction it is considered that the hoods are too long with inadequate control and that the savings achieved are probably due to the extra output.

The electricity savings could not be explained as no changes had been made in the operation such as the shutting of dampers and shutting down of fans etc., as claimed at the other two plants. It must be assumed that it is an output effect.

In 1987 it was suggested that the possibility of replacing the main cyclones by electrostatic precipitators should be assessed. In particular the use of EP's on the No.4 strand of SP2, which was then only a proposal, was particularly supported. It would appear that no assessment has been made and that SP2 No.4 is being fitted with cyclones.

It is also disappointing that bed heights have not been increased and are all still at 300mm. It was stated that they could not be increased physically, but modifications to pallet sides etc must be possible. Apparently there is now some thinking that bed heights might be increased to 350mm and perhaps 400mm later, and Strand 4/SP2 was said to be designed for 450mm.

Three years ago the adoption of a rational screening system was pressed. That is hot screens, cold screens, and furnace screens should have apertures of between 5 or 6 mm. There has been no change and screen mat apertures are still too large. One hot screen has been plated over on SP1 although SP2 would appear to be the better plant for this trial. There had been no detrimental result, so the other three ought to be modified to determine the effect on return fines levels. The No.4 strand at SP2 is to be commissioned without a hot screen and at SP2 a new cold screen is being installed where it is proposed to screen at 5mm and 20mm. So progress is expected in the future.

The hearth layer equipment on SP2 is still out of commission and re-instatement is being considered. Trials are being conducted with stamped mild steel grate bars and high chrome bars have not been used.

A brief visit was paid to No.1 plant. Visually there appeared to be no improvement in instrumentation, housekeeping or plant control. Control of burn through would be virtually impossible with no windbox temperature meters and poor access and visibility at the discharge end.

In summary a very good improvement in energy usage despite slow progress in implementing the proposals made in 1987. There should be a good deal more to be saved. BSP claimed that the implementation of BSC recommendations has given BSP potential savings of Rs 5.3 Crores p.a. at an investment cost of Rs 1.4 Crore.

2.3 Blast Furnaces

Output has been increased by 37% but the new No.7 BF has been introduced since 1987, which will account for a large part of the improvement. Coke was reduced by 2%. This is disappointing when considering that there is now a new furnace, better coke quality, better screening and considerable expenditure has taken place on the plant. One reason is that there is one furnace (No.6) operating unbelievably badly with coke rates of over a ton/THM and with blast temperatures as low as 300°C due to poor stove conditions. Another furnace is not operating well either and was suffering from a chilled hearth during the visit.

Blast furnace gas recovery was down by 1% due to the lower coke rate, so that about a quarter of the coke saving was offset. In addition gas to the stoves was up by almost 9% so the coke saving is almost completely offset by the extra gas used and the reduced gas make.

The deterioration in stove gas consumption is particularly serious. The data to give a weighted blast temperature on the old furnaces and No.7 together was not available. But roughly the higher average blast temperature which is mainly due to higher temperatures on No.7 blast furnace would account for no more than half the increase. So the stove efficiency has also deteriorated. The cycle time had been reduced from 4 hours to 2 hours which should help. Energy department made more checks on combustion conditions and audits on hot blast leaks had been carried out and it was claimed that these were virtually eliminated except perhaps on the chimney valves. A visit was paid to the new No.7 and there were audible leaks in the cast house and no doubt the same was true of the other furnaces despite bellows type tuyere stock being fitted on all furnaces.

The recommendation to fit automatic combustion, stove dome and waste gas temperature control has not been implemented except on the new No.7 furnace. The waste gases are allowed to rise to 300°C and this could be reduced at present stove loadings.

The suggestion 3 years ago to operate Nos.4-6 BF's with only 3 stoves has not been adopted.

The 'Hoogovens' stoves fitted to No.7 furnace are however well equipped and it would be interesting to see how the stove gas usage on this furnace compares with the others, after accounting for blast temperature differences and it is recommended that SAIL should make this comparison.

The steam usage for blast production had improved by 8% against the 30% target suggested 3 years ago. Snort valves were no longer used for volume control and smoother blast furnace operation had reduced the need for snorting due to furnace conditions, off-blast etc. The difference between the turbo-blower meters and the furnace meters was reduced by about 10%. This, according to BSP management, has given savings of Rs 4.0 crores p.a.

Process steam was down by 20% due to reduced steam usage in the blast, plus better housekeeping. However the official statistics showed that steam to the blast has increased from about 1.8 to 2.1 T/h/furnace. So perhaps the latter data are more correct as coke rates would be expected to improve if steam in blast had been reduced significantly. On No.7 furnace the blast humidity was about 30 g/m^3.

The gas losses, as determined from nitrogen balances were about the same as before (about 10%).

Overall the net energy used per ton hot metal is hardly changed and is only 0.5% better.

If the special investigations of cold and hot blast losses, gas losses and stove gas consumption, that were proposed 3 years ago, have been carried out they have not been very rewarding and further work is required particularly on stove gas consumption.

A worthwhile improvement has been made in reducing the coke screenings from 7% to 5%, despite improvements to coke screens, at some of the furnaces. This was largely due to the reduction in screen size to 20mm. No deterioration in BF performance has been seen. There is however a reluctance to ease the top size limit due to observations on the furnaces when the crushing plant has not been operating properly.

One of the old furnaces (No.4), as well as No.7 has now got a bell-less top and it was claimed to need 80 Kg/THM less coke than its otherwise identical neighbour. Whilst some did not support this estimate it is the intention to fit such gear at all furnaces. The moveable throat armour at No.6 is no longer in use.

Sinter screening has been improved. The new screens on the high line for SP1 sinter have been mentioned and Nos. 1, 4 and 7 have under-bunker screens. No.6 will similarly be fitted and will also have screens for ore. No.7 furnace was originally fitted with electro magnetic screens similar to those at Bokaro. All four coke screens have been replaced by Schenk screens and 6 of the 8 sinter screens have been replaced.

Coal injection at Bhilai has made no progress. The maximum injection rate was only 15 Kg/THM and that for only 21 days when furnace operation deteriorated. The potential rewards for the successful implementation of this technique are so great that a renewed effort is justified. There was no time to investigate more fully.

It is interesting that silicon level in iron are down to 0.7 - 0.8% at BF7. It is currently at 1.35% on the other furnaces.

A great deal has been done in this area with very little improvement in energy usage. The highest priority is to reduce stove gas consumption. A lower iron/steel ratio has given over 2% saving on a crude steel basis.

2.4 Steelmaking - Open Hearth Shop

Output in the O.H Shop has increased by a very creditable 23% partly or wholly due to the installation of a twin hearth furnace which had just started operation in March 1987. Also it was said that output improved with improved atomisation of the coal tar fuel (CTF) by replacing the compressed air at 3-4 ata with steam at 18 ata. But CTF is only 10% of the heat input. and this must be a minor effect.

Fuel usage has decreased by no less than 37%, this being the main reason for a reduction in total energy of 28%. Again better atomisation has contributed but also the twin hearth furnace due to its lower fuel consumption. Also with fewer open hearth furnaces operating, more labour is available for cleaning checkers on the remaining OH furnaces. One open hearth furnace has been fitted with micro processor combustion control which is claimed to have reduced fuel consumption by over 30%. Although there was no time to go on the shop it is felt that operational discipline must also have improved to achieve these substantial improvements in output and fuel.

Power usage has increased by 28% largely due to the installation of a gas cleaning plant on the twin hearth furnace. As this is of the multi-cyclone wet washer type, power consumption is high. In passing it is relevant to record an apparent reluctance to use electrostatic cleaners. Whilst they do cost more, the power savings usually give a good return on the extra capital.

Steam usage has increased four fold due to the change over to steam atomisation. Oxygen consumption had increased three fold, the jump occurring in 87/88 and is related to the twin hearth furnace commissioned during 86/87.

A second twin hearth furnace has recently been commissioned in January of 1990 and oxygen usage will rise further but overall fuel will reduce very significantly. A third twin hearth furnace will not be possible because oxygen is not available.

The worst feature of the operation is the reduction of waste heat steam recovery by 14% from a very poor base 3 years ago. But as with some of the other aspects the data can be misleading due to the commissioning of the twin hearth furnace in 86/87 as these units do not have waste heat boilers. It was nevertheless admitted that the waste heat boilers were not operating well and that it was intended to turn attention to this area if only to obtain better draughting on the furnaces.

Raw dolomite and limestone had been reduced by over 21% by 88/89 to a level of 82 Kg/ton. The use of raw stone was criticised three years ago. There still seems to be a feeling that a limestone boil is needed, despite oxygen lancing, and burnt lime was said to be in short supply.

The hot metal ratio has however increased, particularly during 89/90. It was stated that hot metal is cheaper than scrap which is in short supply. The hot metal ratio will increase still further with the second twin hearth furnace, off-setting some of its energy advantages.

Summarising there have been some very useful improvements but it was not possible to separate the effects of the twin hearth furnace from improvements in the normal old hearth furnaces, but the data to do this are available to BSP management.

2.5 STEELMAKING - LD

The output has increased by a massive 86%, but the plant was well under utilised 3 years ago due to restricted demand. This latter has been rectified by extending the quality range from the LD/continuous casting route e.g. auto sheet, pipe steel, and rail steel are now made. Current operation was at the rate of 1.6 mtpa, which is a little over the nominal capacity. The average for the 89/90 was about 1.3 mtpa.

Energy consumption in LD steelmaking is low but there had been a reduction in all categories, the most significant being the fuel saving of 38%. These reductions were clearly influenced by the output increase. Some improvements had also been made at the mixers by more careful manual setting of combustion. Ladle heating was improved and a new horizontal ladle station had been installed.

A low hot metal ratio is the most important contribution that LD steelmaking can make towards lower plant energy, by reducing the amount of high energy iron that is needed. The usage was down slightly but was still 970 kg/ton and the lower HM silicon was mentioned as a factor tending to increase hot metal usage. It would appear that the recommendation for a study of hot metal traffic and the use of ladle lids etc had not been carried out, or not acted upon.

Limestone usage for cooling over hot heats was criticised on the last occasion but is still practised. In fact the stone usage had increased from 6.5 to 9.5 kg/TLS. This was excused on the basis of low lime availability but scrap could have been used.

The most disappointing feature was that, after more than 3 years of operation, there were no credits for the LD gas which the plant was designed to collect. It is understood that trials are now being conducted, but a lot of money and energy has been wasted by the delay in using the gas. Based on BSP's budgeted cost for energy in 1989/90 this amounts to a potential loss of some Rs 1 Crore p.a.

The most favourable feature of the steelmaking scene is that the proportion of LD steel has risen from 32 to 41%, with total steel make up by 43%. This means that energy per ton of crude steel is down by 23%. This will be offset by higher iron making energy if the overall scrap proportion is reduced as it clearly has been. BSP claim that a reappraisal of scrap policy together with improvements in ladle heating and turn around times results in a potential saving of Rs 5.8 Crores p.a. but it is not clear which factors have been assessed.

2.6 Continuous Casting

The output is 86% higher than 3 years ago for the same reasons outlined in the previous section. The energy usage is reduced by 16%, the most important component being power reduced by 35%. If the oxygen had not increased five fold the energy saving would have been 35%. due to the higher output and the adoption of cold tundish practice.

Unfortunately through an oversight enquiries were not made regarding the increase in oxygen but it is difficult to comprehend a usage of more than a quarter of that of the LD steelmaking process.

Energy for continuous casting is low and the major effect is the continuously cast proportion of the total semis which has increased from 32% to 46%. The energy usage on the concast plant and the primary mill together has reduced by 0.22 Gcal/TCS or 64%. This mostly arises from the energy savings and lower production ratio at the primary mill.

2.7 Blooming Mill

Output in the blooming mill has increased by 22% with a creditable decrease in energy consumption of more than 32%. The savings have been achieved in all areas e.g. fuel (30%), power (15%), steam (82%) and oxygen (30%). Part of these savings are obviously production related.

Power savings are achieved by minimising the roll idling and increased charge temperature. Percentage cold charging has decreased by some 13% from 86/87 figures. During the discussions BSP stated that the product mix was worse than before. Therefore the performance was better than reflected in the statistics.

Introduction of microprocessor control on soaking pits together with a concerted effort by mill managers to make people energy conscious through publicity and improved disciples has improved fuel consumption. However the new controllers only operate in the orthodox mode. The addition of predictive temperature control would give further savings. Control of cover opening would also be beneficial.

Although effective utilisation of steam and oxygen is being pursued, it is difficult to comment on such large reductions as these are allocated figures.

Even with the improved pit conditions, the policy of keeping 25 soaking pits in operation continues. Although the management recognises that the load can be met by a maximum of 22 pit operation, they feel bunching of heats makes it impracticable The problem warrants a detailed investigation as substantial savings can be made in this area.

It is pleasing to see that most of the BSC recommendations have been adopted and creditable improved production and energy savings achieved. However, some of the recommendations have only been partially implemented and these should be pursued in full.

2.8 Billet Mill

The output is 38% higher and the energy usage is 37% less than three years ago mainly due to the higher throughput.

BSP claim that improvement in mill operation offered energy savings of Rs 26.7 Lakh for the year 1989/90.

2.9 Rail and Structural Mill

Output in the Rail and Structural Mill increased by 17% over the three years; the best production figures were for 1988/89. For the same period the energy consumption per ton improved by almost 27%. Although steam and oxygen figures are by allocation, 30% savings in fuel and a 9% saving in power is metered.

At the time of the last visit the furnaces were in their worst condition and were scheduled for capital repairs. BSC recommendations have been implemented. Major savings have been achieved through improved skid insulation (Potential: Rs 90 Lakh p.a.), implementing microprocessor based controller (Potential: Rs 25 Lakh p.a.) and routine maintenance. Incorporating a delay strategy will further improve savings.

Because the production ratio (mill tons/crude steel tons) is down the energy savings on a crude steel basis is even higher at 37%. However, it is important that two furnace operation should be carried out whenever possible rather than the three furnace operation presently being pursued.

2.10 Merchant Mill

The story is very similar to the other mill areas. The output is 10% higher than three years ago with an energy saving of some 8%. This could be mostly associated with increased production. However, the energy saving per ton of crude steel is 27% due to the lower production ratio.

Furnace No.2 is now equipped with micro-processor controllers and the other two furnaces will be similarly equipped. Modified skid insulation has been installed on No.1 furnace, to be extended to other furnaces. In addition No.1 furnace is operating with high emissivity refractory (heat bar) coating.

2.11 Rod Mill

Output from the rod mill is improved by 13% with a total energy saving of some 6% based on rod product but 23% based on crude steel, due to a reduced production ratio. Since the furnace was in a reasonable state when first visited most of the savings can be associated with higher production and improved operation.

2.12 Plate Mill

Due to poor demand the production was low during the first visit. The output is now 56% higher than three years ago and the energy is reduced by 26%. The most important component was power reduced by 55%.

The savings in power are achieved through reduced idling and increased production. Installation of variable speed control on some heavy duty motors has been approved and will offer potential savings of Rs 16 Lakh p.a.

Savings in fuel usage was achieved by operating better furnace schedules, improved skid insulation on No.1 (Potential savings Rs 9 Lakh p.a.), microprocessor control on No.2 furnace (Potential savings Rs 10 Lakh p.a.) and high emissivity refractory coating at No.1 furnace. Further potential for savings exist by implementing BSC recommendations on all furnaces and instituting a delay strategy in the micro process control of the furnaces.

2.13 Steam Generation and Usage

The amount of steam generated from fuel has increased by 21% due to the new power station. The net energy required per ton of steam has increased by 8.0%. This apparent decrease in efficiency is due to greater fuel usage, but really means very little, particularly as all steam is valued thermally at the same level of 0.75 Gcal/ton whatever the steam conditions. If actual steam condition had been used the result would have been more favourable. Also condensate return is not allowed for and hence the 'notional efficiency' on table 2.13 is merely a comparative figure.

Despite the greater steam made the total steam (including waste heat steam) per ton crude steel has dropped to 2.35 ton/TCS, a reduction of 11%. The process steam which excludes all but the net steam used for power production and that used for BF blowing. and is arrived at by difference, and hence includes losses, has decreased by 15% to 0.82 ton/ton crude steel.

2.14 Power Generation

Power generated has increased by 36% due to the new power station.

The net energy usage has decreased by 38%. This can be attributed partly to the more efficient new power station, but this also allows more pass out steam from the old power station. Indeed the energy efficiency is very dependant on the amount of pass-out as is shown in the 88/89 data when net energy usage was lower than in 89/90 due to a greater pass-out proportion.

'Own generation' has increased from 33 to 38% and the electricity per ton of crude steel, although still high, has reduced from 570 kWh/TCS to 490 kWh/TCS, a useful reduction of 13.5%.

2.15 Miscellaneous and Losses

This category represents energy used that has not been allocated to departments (such as Central Workshops and Offices etc) as well as direct energy losses. It is a significant part of the total energy usage and amounted to no less than 10% of the total in 86/87. For 89/90 there has been a dramatic improvement and the energy allocated was reduced by 34%. The proportion of the total energy came down to 8%.

There was a reduction in all components, but electricity and oxygen were the major areas of improvement. How much of the saving is due to reduced usage and how much due to lower losses is not shown in the table but it is possible for the works to take the analysis further. For power and steam, where metering is often inadequate, this would not be very rewarding, but for oxygen the separate effect of excess energy for its production, and energy lost due to leakage and blow-off could usefully be separated.

2.16 Works Total

The total energy usage has come down every year from 86/87 and was almost 2.0 Gcal/TCS lower in 89/90, representing a saving of 16.7%. The balanced energy usage was 8.92 Gcal/TCS and was 17% lower than in 1986/87. Note that the 1986/87 data has been changed somewhat from that appearing on the works statistics sheets. There was an over estimate of coke oven by-products which has been added to the totals and steam had been under charged to the coke ovens and blast furnaces and this has been added back to the departments and taken off miscellaneous and losses.

Every department has shown a reduction per unit of product except steam production which may not be significant. Every department has shown a reduction per ton crude steel except for continuous casting where the higher proportion of continuous casting resulted in a slight increase, but of course contributed to an overall decrease in energy.

Of the total saving of 1.95 Gcal/TCS, the "miscellaneous and losses" contributed the largest share with 0.394 Gcals. Coke ovens and sinter plant are next with 0.323 and 0.320 respectively and SMS 1 and the blooming mill gave savings of 0.241 and 0.222. These five departments contributed 1.5 Gcal/TCS or 77% of the total savings.

Table 2.17 is a summary of departmental savings on a crude steel basis, and separates the savings into those that are due to production ratio changes and those due to changes in departmental efficiency.

Of the total savings of 1.95 Gcal/TCS about 0.45 is contributed by favourable changes in production ratios so that about 1.5 Gcal are saved due to better departmental performances.

Of the 0.45 Gcal/TCS which was saved due to variable production ratio the coke ovens, sinter plant and blast furnaces account for 0.31 Gcal/TCS. Melting shops for 0.02 and continuous casting and primary mills for 0.05 Gcal/TCS. These were the major contributors under this heading.

All departments except Steam generation achieved higher efficiency. The Sinter plant, Steelplant, Plate mill, Primary mill and Coke ovens being the most outstanding.

BHILAI STEEL PLANT
ENERGY CONSUMPTION BY PROCESS (AND RELATED DATA)

TABLE 2.1 COKE OVENS	86/87	87/88	88/89	Apr 89 Feb 90 (89/90)	Difference 86/87 & 89/90 Gcal/T	%
Output kT/a Gross Coke	2326.7	2354.1	2780.5	2643.5		
				(2883.8)		+24
Heat Input						
Charge Coal, Gcal/TP	8.928	8.855	8.89	8.938	+0.010	+0.1
Under Firing, Gcal/TP	0.908	0.955	0.884	0.888	-0.02	-2.2
Power, Gcal/TP	0.055	0.053	0.077	0.076	+0.021	+38.2
Steam, Gcal/TP	0.254	0.268	0.323	0.325	+0.071	+28.0
TOTAL INPUT	10.145	10.131	10.174	10.227	+0.082	+0.8
Heat Output						
Coke, Gcal/TP	6.165	5.964	6.138	6.229	+0.064	+1.0
Gas, Gcal/TP	1.532	1.564	1.585	1.608	+0.076	+5.0
By-Products, Gcal/TP	0.383	0.398	0.45	0.449	+0.066	+17.2
TOTAL OUTPUT	8.08	7.926	8.176	8.286	+0.206	+2.5
Net-Usage Gcal/TP	2.065	2.205	1.998	1.941	-0.124	-6.0
Energy yield loss Gcal/TP	0.848	0.929	0.714	0.652	-0.196	-23.1
Energy yield loss % of coal input	9.5	10.5	8	7.3	-	
Energy Net of yield loss	1.217	1.276	1.284	1.289	+0.072	+5.9
Production Ratio (Coke/Crude Steel)	1.04	0.98	0.93	0.94		-9.6
Gcal/Ton Crude Steel (act)	2.148	2.161	1.858	1.825	-0.323	-15.0
Yield, G. Coke/Coal*	0.765	0.77	0.764	0.768		
Yield, BF Coke/G.Coke*	0.897	0.896	0.893	0.895		
BF Screen Loss (%)	7	8.18	5.68	5.1		
Overall Screenings, % of G.Coke*	17.6	17.8	15.8	15.1		
Imported Coal, %	27.8	26.9	36.3			
Micum 10 (old batteries)	11.8	11.6	11.1	11.2		
Micum 10 (No 9 Battery)			8.8	8.9		
+ 80mm in BF Coke %	21.5	11.7	15.5	16.7/11.0		

* G.Coke = Gross Coke

BHILAI STEEL PLANT
ENERGY CONSUMPTION BY PROCESS (AND RELATED DATA)

TABLE 2.2 SINTER PLANT	86/87	87/88	88/89	Apr 89 Feb 90 (89/90)	Difference 86/87 & 89/90 Gcal/T	%
Output kT/a	2642.5	2664.8	3190.1	3283.3 (3580.6)		+35.0
Coke Breeze Gcal/TP	0.679	0.565	0.53	0.491	-0.188	-27.7
Ignition Fuel Gcal/TP	0.108	0.1	0.083	0.078	-0.030	-27.8
Power Gcal/TP	0.152	0.148	0.127	0.11	-0.042	-27.6
Steam Gcal/TP	0.003	0.002	0.003	0.002	-0.001	-33.3
TOTAL USAGE	0.941	0.816	0.743	0.681	-0.260	-27.6
Production Ratio TP/TCS	1.18	1.1	1.06	1.16		
Gc/TCS (act)	1.11	0.898	0.788	0.79	-0.320	-28.8
Coke Breeze kg/TP SP1	115	107	96	76		
Coke Breeze kg/TP SP2	105	94	86	78		
Flue Dust (SP1 only) kg/T.P	38	39	26	49		
Return Sinter %	39.5	39.2	36.7	34		
% Utilization } SP1	75.6	73.1	82.9	85.3		
(% of calender) } SP2	73	68	82	81		

TABLE 2.3
BLAST FURNACES

	86/87	87/88	88/89	89/90	Gcal/T	%
Output kT/a	2510	2556.1	3306.2	3147.7 (3433.9)		+37.0
Coke Gcal/TP	4.387	4.318	4.2	4.308	-0.079	-1.80
Gas to Stoves Gcal/TP	0.564	0.597	0.61	0.613	+0.049	+8.69
Steam for Blast Gcal/TP	0.497	0.505	0.476	0.459	-0.038	-7.65
Process Steam Gcal/TP	0.096	0.08	0.081	0.077	-0.019	-19.8
Power Gcal/TP	0.032	0.076	0.084	0.082	+0.050	+156.3
Total Input	5.576	5.576	5.451	5.539	-0.037	-0.66
B.F. Gas Gcal/TP	1.799	1.802	1.644	1.781	-0.018	-1.00
Net Energy Usage Gcal/TP	3.777	3.774	3.807	3.758	-0.019	-0.50
Coke - Gas Gcal/TP	2.588	2.516	2.556	2.527	(-0.06)	(-2.35)
Production Ratio	1.13	1.06	1.1	1.11		
Gcal/TCS (act)	4.268	4.000	4.188	4.171	-0.097	-2.27
Slag Volume kg/t	470	487	433			
Limestone kg/t	20	26	22			
Sinter kg/t	1037	1021	910			
Blast Temperature Deg.C(1-6)	770	792	807	768		
Blast Temperature Deg.C (No.7)			886	919		
Steam Usage T/h/Fnce	1.79	1.95	2.03	2.12		
H.M. Temperature Deg.C (1-6)	1367	1371	1377			
H.M. Temperature Deg.C (No.7)			1405			

BHILAI STEEL PLANT
ENERGY CONSUMPTION BY PROCESS (AND RELATED DATA)

TABLE 2.4 SMS I (OPEN HEARTH)				Apr 89 Feb 90	Difference 86/87 & 89/90	
	86/87	87/88	*88/89	(89/90)	Gcal/T	%
Output kT/a	1525.6	1657.5	1917.1	1715.5		
				*(1871.5)		+23.0
Energy Input Gcal/TP						
Fuel	1.151	0.991	0.914	0.725	-0.426	-37.0
Power	0.057	0.078	0.068	0.073	+0.016	+28.1
Steam	0.01	0.008	0.038	0.042	+0.032	+320.0
Oxygen (@ 2500 /m3)	0.048	0.153	0.147	0.148	+0.100	+208.0
Boiler Coal	0.09	0.1	0.089	0.076	-0.014	-15.6
Total Input	1.354	1.33	1.255	1.089	-0.265	-19.6
Steam Recovery	0.1	0.072	0.084	0.086	-0.014	-14.0
Net Usage Gcal/TP	1.254	1.258	1.171	1.003	-0.251	-20.0
Production Ratio	0.68	0.69	0.64	0.61		
Gcal/TCS (act)	0.853	0.868	0.749	0.612	-0.241	-28.3
Hot Metal/TP (Tons)	0.88	0.837	0.884	0.93		
Scrap t/TP	0.23	0.25	0.232			
Limestone kg/t	58	45	43			
Raw Dolomite kg/t	46	44	39			

TABLE 2.5
SMS II (LD)

Output kT/a (liquid steel)	704.5	813.8	1177	1201.3		
				(1310.5)		+86
Fuels Gcal/TP	0.324	0.249	0.186	0.201	-0.123	-38.0
Power Gcal/TP	0.087	0.078	0.063	0.062	-0.025	-28.7
Steam (@ 750/T) Gcal/TP	0.04	0.047	0.021	0.019	-0.021	-52.5
Oxygen Gcal/TP	0.168	0.17	0.164	0.167	-0.001	-0.59
Total Input Gcal/TP	0.619	0.542	0.437	0.449	-0.170	-27.5
Production Ratio	0.32	0.34	0.39	0.43		
Gcal/TCS (act)	0.198	0.184	0.17	0.193	-0.005	-2.53
Hot Metal/TP kg	982	1005	952	969		
Scrap kg	142	155	183			
Limestone kg	6.6	10.7	10.9	9.5		
Oxygen m3/t	67.4	67.8	63.9	66.9		
SMS (Combined)						
Output	2230	2471.3	3094.1	2916.8		
				(3182.0)		+42.7
LD Ratio %	31.6	32.9	38	41.2		
Gcal/TCS	1.051	1.052	0.919	0.805	-0.246	-23.4

BHILAI STEEL PLANT

ENERGY CONSUMPTION BY PROCESS (AND RELATED DATA)

TABLE 2.6 CONTINUOUS CASTING				Apr 89 Feb 90	Difference 86/87 & 89/90	
	86/87	87/88	88/89	(89/90)	Gcal/T	%
Output kT/a	650	754.5	1080.1	1109.6		
				(1210.0)		+86.0
Fuel Gcal/TP	0.053	0.093	0.065	0.031	-0.022	-41.5
Power Gcal/TP	0.13	0.109	0.095	0.084	-0.046	-35.4
Steam Gcal/TP	0.006	0.007	0.002	0.002	-0.004	-66.7
Oxygen Gcal/TP	0.01	0.028	0.041	0.048	+0.038	+380.0
Total Usage	0.198	0.237	0.203	0.166	-0.032	-16.2
Production Ratio	0.29	0.31	0.36	0.39		
Gcal/TCS	0.058	0.073	0.073	0.065	+0.007	+11.6
% Concast	31.7	32.9	39.1	41.4		
% Ingots	5.5	4.47	2.86			

TABLE 2.7

BLOOMING MILL

Output kT/a	1398.5	1536.9	1682.2	1563.3		
				(1705.4)		+22.0
Fuel Gcal/TP	0.71	0.573	0.51	0.493	-0.217	-30.6
Power Gcal/TP	0.078	0.073	0.069	0.066	-0.012	-15.4
Steam Gcal/TP	0.057	0.044	0.011	0.01	-0.047	-82.5
Oxygen Gcal/TP	0.01	0.01	0.008	0.007	-0.003	-30.0
Total Gcal/TP	0.855	0.7	0.596	0.577	-0.278	-32.5
Production Ratio	0.63	0.64	0.56	0.55		
Gcal/TCS	0.539	0.448	0.334	0.317	-0.222	-41.2
Bloom/Slab yield %	86.2	86.5	87.1			
Track Times hr-min	4-05	3-35	3-40			
Charge Temp. Deg.C 1st half	607	653	648			
Charge Temp. Deg.C 2nd half	558	604	614			
% Cold	27.1	23.6	23.6			

BHILAI STEEL PLANT
ENERGY CONSUMPTION BY PROCESS (AND RELATED DATA)

TABLE 2.8 BILLET MILL (Direct Rolled)				Apr 89 Feb 90	Difference 86/87 & 89/90	
	86/87	87/88	88/89	(89/90)	Gcal/T	%
Output kT/a	812.4	957.6	1021.6	1030.9 (1124.6)		+38.0
Fuel Gcal/TP						
Power Gcal/TP	0.086	0.074	0.07	0.065	-0.021	-24.4
Steam Gcal/TP	0.044	0.032	0.018	0.016	-0.028	-63.6
Oxygen Gcal/TP	0.012	0.011	0.009	0.008	-0.004	-33.3
Total Gcal/TP	0.142	0.117	0.097	0.089	-0.053	-37.3
Production Ratio	0.36	0.4	0.34	0.36		
Gcal/TCS (act)	0.051	0.047	0.033	0.032	-0.019	-37.3

TABLE 2.9
RAIL AND STRUCTURAL MILL

Output kT/a	490.6	535.3	616.7	526.7 (574.6)		+17
Fuel Gcal/TP	0.965	0.851	0.696	0.671	-0.294	-30.5
Power Gcal/TP	0.24	0.223	0.209	0.218	-0.022	-9.2
Steam Gcal/TP	0.065	0.051	0.039	0.04	-0.025	-38.5
Oxygen Gcal/TP	0.003	0.003	0.002	0.002	-0.001	-33.3
Total Gcal/TP	1.273	1.127	0.945	0.032	-0.341	-26.8
Production Ratio	0.22	0.22	0.21	0.19		
Gcal/TCS (act)	0.28	0.248	0.198	0.177	-0.103	-36.8

TABLE 2.10
MERCHANT MILL

Output kT/a	335.1	400.7	374.6	338.6 (369.4)		+10
Fuel Gcal/TP	0.766	0.698	0.658	0.709	-0.057	-7.4
Power Gcal/TP	0.18	0.16	0.179	0.182	+0.002	+1.1
Steam Gcal/TP	0.06	0.047	0.038	0.038	-0.022	-36.7
Total Gcal/TP	1.006	0.905	0.875	0.929	-0.077	-7.7
Production Ratio	0.15	0.17	0.12	0.12		
Gcal/TCS (act)	0.151	0.154	0.105	0.111	-0.04	-26.5

BHILAI STEEL PLANT
ENERGY CONSUMPTION BY PROCESS (AND RELATED DATA)

TABLE 2.11 ROD MILL				Apr 89 Feb 90	Difference 86/87 & 89/90	
	86/87	87/88	88/89	(89/90)	Gcal/T	%
Output kT/a	361.6	351.9	372.2	373.4		
				(407.3)		+13
Fuel Gcal/TP	0.542	0.547	0.527	0.511	−0.031	−5.7
Power Gcal/TP	0.289	0.293	0.29	0.272	−0.017	−5.9
Steam Gcal/TP	0.026	0.022	0.026	0.023	−0.003	−11.5
Total Gcal/TP	0.857	0.862	0.843	0.806	−0.051	−5.95
Production Ratio	0.16	0.15	0.12	0.13		
Gcal/TCS (act)	0.137	0.129	0.101	0.105	−0.032	−23.4

TABLE 2.12
PLATE MILL

Output kT/a	374.2	380.6	573.8	535.7		
				(584.4)		+56
Fuel Gcal/T.P	0.965	1.058	0.897	0.909	−0.056	−5.8
Power Gcal/TP	1.213	1.124	0.659	0.548	−0.665	−54.8
Steam Gcal/TP	0.081	0.11	0.048	0.046	−0.035	−43.2
Oxygen Gcal/TP	0.017	0.112	0.005	0.007	−0.010	−58.8
Total Input Gcal/T.P	2.276	2.405	1.608	1.511	−0.765	−33.6
Recovered Steam	-NR	0.[illegible]1	0.06	0.051	+0.051	
Net Energy Usage Gcal/TP	2.276	2.334	1.548	1.46	−0.816	−35.8
Production Ratio	0.17	0.16	0.19	0.19		
Gcal/TCS (act)	0.387	0.373	0.294	0.277	−0.110	−28.4

TABLE 2.13
STEAM GENERATION

Output kT/a	5677.2	5395.4	6281.2	6412.2		
				(6995.1)		+21
Fuel in Gcal/TP	0.78	0.817	0.786	0.793	+0.013	+1.7
Power Gcal/TP	0.057	0.059	0.055	0.051	−0.006	−10.5
Total Input	0.837	0.876	0.841	0.844	+0.007	+0.7
Steam output Gcal/TP	0.75	0.75	0.75	0.75		
Net Usage Gcal/TP	0.087	0.126	0.091	0.094	+0.007	+8.0
Production Ratio	2.55	2.24	2.1	2.27		
Gcal/TCS (act)	0.222	0.282	0.191	0.211	−0.011	−4.95
Boiler Coal %	73	69.7	64.8	53.8		
Notional Boiler Efficiency %	89.6	85.6	89.2	89		
Total Steam (inc W.H & Losses)kT/a	5880.2	5590.8	6541.8	(7249.9)		
Net Steam for power & blowing	3731.5	3407.2	4064	(4726.4)		
Process Steam (by diff)	2148.6	2183.5	2477.8	(2313.2)		
Process Steam T/TCS	0.963	0.905	0.827	0.819		−15.0
Total Steam T/TCS	2.637	2.318	2.183	2.352		−10.8

BHILAI STEEL PLANT
ENERGY CONSUMPTION BY PROCESS (AND RELATED DATA)

TABLE 2.14 POWER GENERATION				Apr 89 Feb 90	Difference 86/87 & 89/90	
	86/87	87/88	88/89	(89/90)	Gcal/T	%
Output Gwh/a	421.9	348.7	452.7	527.4 (575.3)		+36
Steam input Gcal/Gwh	4.386	4.281	5.523	5.035	+0.649	+14.8
Power output Gcal/Gwh	3	3	3	3		
Steam output Gcal/Gwh	0.708	0.652	2.266	1.615	+0.907	+128
Net Usage Gcal/Gwh	0.678	0.63	0.257	0.42	-0.258	-38.1
Production Ratio Gwh/TCS	0.19	0.14	0.15	0.19		
Gcal/TCS (act)	0.128	0.088	0.039	0.08	-0.048	-37.5
Notional Efficiency %	36	35.3	56.6	49.2		
Total Works Power Usage Gwh/a	1269.2	1403.9	1529.9	1389.7		
% own Generation	33.2	24.8	29.6	37.95		
kWh/TCS	569	582	510	492		-13.5

TABLE 2.15
MISCELLANEOUS & LOSSES

Fuels Gcal/TCS	0.159	0.141	0.114	0.121	-0.038	-23.9
Power Gcal/TCS	0.889	0.833	0.725	0.702	-0.187	-21.0
Steam Gcal/TCS	0.23	0.173	0.158	0.152	-0.078	-33.9
Oxygen Gcal/TCS	0.239	0.071	0.065	0.058	-0.181	-75.7
Total Gcal/TCS	1.517	1.217	1.061	1.033	-0.484	-31.9
Oxygen credit Gcal/TCS	0.342	0.277	0.253	0.253	-0.089	-26.0
Net Miscellaneous & Losses Gcal/TCS	1.175	0.94	0.808	0.781	-0.394	-33.5

TABLE 2.16
WORKS TOTAL

Crude Steel Output kT/a	2230	2112	2997.2	2825.2 (3082.0)		+38
Gcal/TCS actual	11.754	10.96	9.977	9.78	-1.954	-16.7
Gcal/TCS Balanced	10.751	10.147	9.248	8.923	-1.828	-17.0
Gcal/TCS (Balanced) OH Route		10.022	9.393	9.057		
Gcal/TCS (Balanced) LD/CC/PM Route		10.385	8.991	8.719		

TABLE 2.17

BHILAI STEEL PLANT ANALYSIS OF DEPARTMENTAL CHANGES			
COMPARISON OF 86/87 AND 89/90	CHANGES/TON CRUDE STEEL		
DEPARTMENT	DUE TO EFFICIENCY Gcal/TCS	DUE TO PROD.RATIO Gcal/TCS	TOTAL Gcal/TCS
Coke Ovens	0.116	0.207	0.323
Sinter Plant	0.302	0.018	0.32
Blast Furnaces	0.021	0.076	0.097
S.M.S. I	0.153	0.088	0.241
S.M.S. II	0.073	(0.068)	0.005
S.M.S. Combined	0.226	0.02	0.246
Continuous Casting	0.012	(0.019)	(0.007)*
Primary Mill	0.153	0.069	0.222
C.C. AND P.M. Combined	0.165	0.05	0.215
Billet Mill	0.019	NIL	0.019
R & S Mill	0.065	0.038	0.103
Merchant Mill	0.009	0.031	0.04
Rod Mill	0.006	0.026	0.032
Plate Mill	0.155	(0.045)	0.11
Steam Generation	(0.014)	0.025	0.011
Power Generation	0.048	NIL	0.048
Miscellaneous and Losses	0.394	NIL	0.394
TOTAL	1.512	0.446	1.958

* FIGS IN BRACKETS INDICATE ADVERSE CHANGES

PART 3

ENERGY MONITORING STUDY

ROURKELA STEEL PLANT (RSP)

ENERGY MONITORING - RSP

CONTENTS

TABLES

TABLES Continued

3.0 ASSESSMENT REPORT ON ROURKELA STEEL PLANT

3.1 Coke Ovens

Gross coke output has increased by 9% without any plant additions.

The net energy has come down by a massive 25% as detailed in Table 3.1.

Underfiring is usefully reduced by 7%, which is attributed to fewer fuel changes, more regular combustion checking, better temperature control and more regular pushing, although no quantitative data were obtained. Steam heating of the coke oven gas had been introduced to prevent burners and control valves clogging.

Power was down by 14% and could have been influenced by the progress made in changing over to steam drives, instead of the electrical alternatives on the exhausters. Now more than 60% of the exhausters are using back pressure steam drives due to the improved steam conditions now available. This in turn is due to the lower steam usage on the works as a whole. This proportion is expected to increase in future.

Steam usage was down by 17%. This would not be significantly affected by the move towards more steam drives as they are operated as back pressure units. The only explanation was better housekeeping, such as attention to steam leaks etc.

Gas yields were greatly improved by 10% and by-products by 7%. Gas calorific value was 12% better. This was attributed to the better 'health' of the batteries overall as a bad battery had been taken out and a rebuilt one introduced in its place. Also better maintenance of oven brick work by spraying and gunning together with better door sealing arising out of the introduction of hydrojet door cleaning on some batteries, and the more recent introduction of mechanical frame cleaning. A full installation of these features is planned.

The key item on coke ovens is the 'energy yield loss' factor. That is the coal heat input minus heat output in coke, gas and by-products. This has improved from a very poor level of 14% of the coal input in 86/87 to 8.6% in 89/90. This represents a saving of 0.532 Gcal/TP accounting for 87% of the overall saving. About a third of the improvement in energy yield is due to the improved yield of gas and by-product and the rest is because of improved coke from coal yields, but how this had been achieved was obscure. Regular weighing of the charging car is now practised and 20-30% of all ovens are weighed and the weighbridges are calibrated more frequently. This exercise indicates that coal weights are perhaps under estimated. Thus more coal may be charged to the ovens than the accounting system assumes, which could explain the improvement. But as the levels of energy yield loss are still high and as it is not clear how the improvement has been made more work is required. The special exercise to solve this problem has apparently not been carried out as suggested in the first report. Although it is planned to install electronic weighers on the blast furnace coke belts. As this is a corporate problem perhaps R & D could become involved.

The screening loss at the coke ovens has slightly deteriorated despite improved coke quality, better screen maintenance and some reduction in the bottom size screen mats. Coke quality has been improved by better coal crushing so that the % - 3mm has improved from 73.3% to 77.8% and the M10 from 10.5 to 9.9. This has been done by better maintenance on the coal crushing plant.

Two of the five BF coke screens have been changed from 40mm to 35mm. This is disappointing as 3 years ago apertures of 25mm were suggested. As it is now understood that screens at the blast furnaces have been reduced to 20mm it is irrational to screen at 35mm at the ovens. This practice should be compared to Bhilai where 20mm screens are used at the coke ovens and at the blast furnaces.

Blast furnace screenings have however reduced so that overall the screen loss has been improved from 26% to 22%. This is a very useful improvement but still far short of BSP and world practise and requires urgent action to take screen mat sizes down to 25 or even 20mm.

There are plans for various improvements which are listed briefly below

(a) Gooseneck temperature measurements to indicate the end of coking.
(b) coke temperature measurement in the guide and in the quenching car.
(c) flue gas analysers.
(d) on-main charging.
(e) briquette charging - to improve the M10 by 1.5
(f) stamp charging - to give M10 improvements of 3.5.
(g) improve segregation of coke types.

These improvements should reflect favourably on the energy usage, but the important area is to reduce still further the energy yield loss and to reduce screen sizes in order to reduce screenings loss.

3.2 Sinter Plant

Output has improved by no less than 24% and energy consumption has decreased by a very creditable 37% (See Table 3.2).

The most important component is coke breeze, which is 43% lower and accounts for 87% of the overall saving. This was attributed to better coke breeze crushing which was very poor in the past. Some of the statistics suggested that breeze sizing had deteriorated but it was explained that the previous sampling point, at the crusher discharge was heavily biased and has been changed to the raw materials feed bins. The + 3mm used to be as bad as 40-45% and was now 20 - 25% and the + 5mm had come down from 25-30% to about 5%. This had been achieved by better maintenance and attention to detail at the crushing plant. Whilst this is creditable there is room for still more improvement in this area. Other factors must also have contributed. Rubber liners in the mixing drums have improved balling, distribution into the roll feeder hopper has been improved, and more recently the angle of the cut off plate has been made shallower to give better bed segregation. The deeper beds will have contributed more recently and reducing stoppages will have had an important effect.

Ignition fuel is down by 24%, but is still high. Hoods have been lengthened and high pressure side burners installed with auto controls. Whilst some of these modifications would save fuel the move to longer hoods is considered to be detrimental and shorter hoods should be tried. A great deal of the saving must be output related.

The reduction in power consumption of 14% is also partly output related but economies have also been introduced in that main fan dampers are closed for stops exceeding 15 minutes and the fans are stopped altogether if the strand is off for 3 hours or more. Cooler fans are stopped after half an hour.

Screen mat sizes were in the past too big but hot screens have been reduced to 6mm and cold screens to 18 and 6mm, with the intermediate size range being for hearth layer. One blast furnace has a sinter screen and others will follow. These changes have only been introduced relatively recently and will have contributed towards reducing the return fines from 40 to 36.5%.

Suctions under the strands have been increased from 300/350 mm w.g to 550/600 mm w.g. This was achieved by replacing many pallets during a capital repair and sealing many leaks. As a result the bed heights have been increased from around 380mm to 420/430mm. It is intended to fit heavier drop bars in the pallets by doubling the weight to obtain better sealing. The economics of replacing the multi-cyclones by electro filters, have apparently not been examined, and nor have the possibilities of fan modifications.

Higher quality grate bars of 24/27% chrome have been introduced and grate bar delays have come down dramatically from 270 hours in 88/89 to 35 hours in the current year.

Delays overall have dropped from almost 5000 hours in 86/87 to 2700 in the 11 months of 89/90.

Future plans include:

(a) Modifying the hearth layer system to obtain more accurate control.

(b) Screening out under size fractions of coke breeze prior to crushing.

(c) Modifications to raw material proportioning by load cells on the bins etc, including auto correction for coke moisture

(d) The addition of bed blending, to incorporate a large part of the coke.

There has been very encouraging progress in this department so that it is now the best of the three plants in energy terms when it was the worst 3 years ago. Ignition hood design has been criticised and some of the modifications have taken a long time to implement.

3.3 Blast Furnaces

Output has hardly changed and is only marginally higher than in 86/87.

The net energy usage has improved only slightly by 0.11 Gcal/THM or 2.5%.

Coke has reduced by 6.6% but as a consequence B.F gas recovery is lower by 14% so that 75% of the coke saving is offset.

Stove gas has increased by almost 4% despite a reduction in blast temperature of some 30°C, the reduction in coke rate and the installation of cold blast main insulation. As it was also claimed that only 2 stoves were in use for most of the time and instrumentation had been replaced on two furnaces, the inference must be that stove efficiency or hot blast leaks or both have worsened and while there was no time to investigate further during the visit it is clearly an area requiring urgent attention.

Steam used for blast production was excessive 3 years ago and several actions have been taken to reduce this, including better co-ordination between the furnaces and the blowing house, the reconditioning of the turbo blowers and attention to steam, cold blast and hot blast leaks. The overall saving was only 4% despite the reduced coke rate and so cannot be considered a satisfactory situation and requires further attention.

Indeed the carbon and nitrogen balances carried out by the Energy department have shown some deterioration. The detailed audit over the whole area of blast and gas losses, which was suggested three years ago does not appear to have been done.

Process steam consumption has been reduced significantly by 26% which is said to be due to better housekeeping and reduced blast humidification. It was not possible to check the latter claim but the reduced coke rates with lower blast temperatures would support it. There had also been an increase in the sinter proportion from 728 kg/THM in 86/87 to 826 in 88/89 and higher still in the current year. This was made possible by better sinter plant outputs.

The furnaces are still not driving and slips are frequent (contributing to gas losses). On the last visit it was suggested that different charging sequences might be tried and different layer thickness have in fact been used with the help of gas probes. Layer charging is often the most efficient method but can inhibit furnace drive if burden materials are not adequately sized. Other charging methods could be tried. It was also suggested that controlled slips, induced by regular checking, although far from ideal, would be better than uncontrolled slips. There appeared to be a willingness to at least think about this.

Raw limestone had reduced from 125 kg/THM to 113 in 88/89 but is still high. This was partly due to the sinter proportion differing from furnace to furnace so that the flux addition at the sinter plant had to suit the higher sinter furnace. There would be useful gains by levelling out sinter rates and charging more flux to the sinter.

Hot metal silicon was virtually unchanged at about 1.6%.

Blast temperatures were rather lower than previously but it was not clear whether this was in response to a suggestion three years ago to opt for lower and steadier blast temperatures rather than be at the mercy of gas availability; but the general impression was that the suggestions had not been properly evaluated and although it is not so relevant now the question should still be asked again.

Three years ago there was an attempt to encourage the operators to use a wider size range of coke - if only experimentally - in the interests of obtaining a higher yield of skip coke from gross coke. Because the top size at this works is 100mm compared to 80mm nominal at the other two works the emphasis was on reducing the bottom size limit and establishing a more rational screening regime. In 1987 the coke oven screens were 40mm and the blast furnace screens 25mm. Now 2 of 5 coke oven screens have been reduced to 35mm and the blast furnace screens to 20mm. Progress has been very slow and the screens at the coke ovens should be of the same size as at the furnaces (eg at BSP both are 20mm). There is a reluctance to make this change due to the wide size range of the coke, which seems to be an exaggerated fear. Trials should be carried out with some urgency. If 20/25mm screens create any difficulties then reducing the top size to a nominal 80mm would be more logical than maintaining coke oven screens at 35/40mm.

Water sprays are now used for cooling the furnace tops rather than steam, contributing to the reduction in process steam usage. Nitrogen for purging and bell sealing has not been introduced due to a site shortage of nitrogen, but it is used for cooling/purging the gas probes. Time did not permit any detailed assessment of the probe results.

Trials were in hand of improved trough materials in order to minimise delays and secure better casting consistency, and the use of water less tap hole clay was being considered, although it would be difficult to justify with low blast pressures, particularly if such materials necessitated new clay guns.

Overall there has been a useful reduction of energy in this area, particularly as the lower coke rate will save energy at the coke ovens and as the iron/crude steel ratio has been reduced the saving on a crude steel basis is 0.26 Gcal/TCS or 5%. Nevertheless the failure to assess previous suggestions and the delay in implementing others (eg coke sizing) must be criticised. There is plenty of scope for further improvements, particularly on the stoves and on gas and blast losses.

3.4 Steelmaking - Open Hearth

Output has increased by 19% and energy consumption has decreased overall by 21%. (See Table 3.4)

The major factor is the reduced fuel usage which accounts for most (98%) of the energy saving. The reasons for the fuel saving are firstly the increased output, secondly the steam main supplying the atomising medium has been replaced giving an increase in pressure from 7 Kg/cm^2 to 8-9 Kg/cm^2. Thirdly higher calorific value of the coke oven gas has helped slightly. But undoubtedly an important factor has been the introduction of the Korf process of back-wall lancing. Currently only one furnace out of three operating can use this system but the percentage of Korf operation has increased from 22 to 34%. This process gives a tap to tap time of 5 hours and uses only half the fuel of the conventional furnaces. It is planned to install another valve station so that future operation will consist of using only the two Korf furnaces, which should give further improvement in energy consumption.

Power consumption has increased by 31%, mostly in 89/90. The reason was not discovered. Steam has been reduced by 14%, for a variety of reasons; better steam conditions, proportionally less tar fuel and presumably greater Korf operation. Oxygen has also reduced by 10%, attributed to better utilisation in the Korf furnace.

Although scrap is dearer than hot metal the use of scrap is maximised for maximum output and has increased from 533 to 562 kg/TCS with parallel reductions in hot metal, helping to reduce the hot metal/crude steel ratio and save energy overall.

3.5 Steelmaking - LD

The output of LD steel in 1989/90 was running at a rate slightly less than in 86/87, due, it is understood, to a shortage of iron as a blast furnaces had been off. The output in 88/89 was much higher, being some 8% over the base year.

Whilst the LD process does not consume very much energy it was disturbing to find that the usage was some 8% higher than in the base year. This was largely due to an increase in fuel and power of 14% and 27% respectively, offset by a reduction in oxygen. The change in power was claimed to be due to a change in allocation and no reason could be given for the fuel increase as economies were claimed for the mixers and for ladle heating. This shifted the responsibility to the lime burning plant. It was disappointing that these facts did not appear to be appreciated by the operators, indicating that energy awareness could still be improved in some areas.

The most important factor on an LD plant is to reduce the hot metal usage so that less high energy hot metal is needed. There has been progress in this field with a reduction from 1051 kg/TCS to 1030 kg/TCS in the current year. The current level is still high, but problems still exist due to low metal temperatures. The iron is said to cool from 1350°C to 1260°C between the blast furnaces and the melting shop. The possibility of improving metal temperature by slicker movement of ladles and by insulated lids etc. was mentioned in the first report, but apparently had not been followed up. As this works seems to be iron constrained there is a greater incentive to reduce hot metal usage as steel output could be increased as well as saving energy. Hence RSP could well be the SAIL leader in exploiting high scrap techniques.

The proportion of LD steel had fallen in the current year (see earlier comment) so that the savings on the total steel make were only 1.5%, rather than the 4.8% that would have been achieved if the 86/87 ratios had obtained. However as the O.H furnace used less iron the total energy to the crude steel stage is lower on the O.H route than the LD (5.22 Gcal, compared with 7.37 Gcal)

It is of course still preferable, energy wise, to favour the LD as long as the scrap proportion overall is not reduced.

Cooling overhot heats by adding lime is still practised and alternatives (e.g. scrap) should be sought.

On the mixers the general health was said to be very much better and air gas ratio is set manually from time to time. Savings of the order of 15% were claimed. Ladle heating had been improved by fitting new burners resulting in heating times being reduced by half. Sliding gates were now in use so the stopper oven is not required.

The longer term plan is to build a new LD shop with 2 vessels but to retain 3 vessels in the old shop. It was suggested three years ago that a relatively small increase in the vessel size on the new shop would enable all the old converters to be scrapped and that this should be considered. It is not known whether it has been assessed but the original plan to retain part of the old shop has not changed.

3.6 Primary Mill

Output has increased by 9% and the energy consumption has decreased overall by 8% (See Table 3.6).

The major factor is the reduced fuel usage which accounts for most of the energy savings. The reason for the fuel savings can mostly be explained by the increase in output. The number of pits operating remain the same at 22 as during the last visit. It was suggested that theoretically 10 pits would suffice but because of the erratic scheduling a buffer of 50% more should be sufficient. The scheduling is still erratic but management agrees that 22 pit operation could be cut down to 17 pits. An effectively operated scheduling strategy would be expected to cut fuel consumption by up to 5% with a reduced scale loss.

Cold charging has not improved significantly. Track time has however improved, with heats at less than 3.5 hours increasing from 49% to 67%. This will contribute towards the energy saving and the 18% reduction in heating time, together with the improved insulation and combustion control.

Power savings of 4% can be accounted for partly due to the increase in output and partly due to improved housekeeping. The RSP Primary mill was the best of the works studied three years ago. The improvement made has allowed this lead to be maintained. Progress in implementing the original proposals has been slow in such matters as scheduling and reducing the number of operating pits.

3.7 Plate Mill

This is one of the few areas visited where the output has decreased (6%) over the last three years. The overall energy consumption has increased by 22%, a substantially higher figure than expected.

The major factor in the increase of energy consumption is fuel usage. Some of this could be explained due to the poor reliability of instrumentation in this area and partly due to the failure of the recuperator on the normaliser. However the quoted figures are high and the trend is unacceptable unless there have been major changes in the product mix. Therefore effort is needed to improve energy consumption both through improved fuel usage and reduced losses.

3.8 Hot Strip Mill

Output has increased by 21%. Despite this the energy consumption has decreased overall by only 1% (See Table 3.8).

During discussions RSP explained that the product mix was very different this year both in terms of size and weight.

Fuel savings of 4% have been achieved through improved skid insulation of No.2 and No.3 furnaces and increased output. All three strip mill furnaces are in use because they are still not reaching their design capacity. Installation of new burners with improved atomisation and a new recuperator should give the capability of meeting the demand with two furnace operation giving an energy saving of more than 25%.

An increase in power consumption of 2.5% can partly be explained by the furnaces not reaching the required drop out temperature. In addition mill availability is still a problem with too much downtime.

Improved lighting management and installation of variable speed control on heavy duty motors will further reduce power consumption.

RSP stated that the earlier recommendations to reduce both power and water losses in the strip mill had been implemented by issuing written operating procedures and these were especially adhered to during stoppages. However statistical data does not show the expected improvement. Effort is needed to make sure that the operating procedures are followed.

Implementation of delay strategy on No.1 and No.2 furnaces, soon to be commissioned, will improve energy consumption.

3.9 Pipe Plant (Spiral)

Data shows that although output has increased by 26% power usage has increased by 55% (see Table 3.9).

In the specialist areas where metering is questionable it is difficult to comment, but if this is realistic it requires explanation.

3.10 Electric Sheet Mill

Output has decreased by 3% and the energy consumption has increased overall by 18%.

In the context of the works as a whole, the thermal consumption of this plant is not very high. With the usual problems of instrument malfunction, lack of data on thermal input compounded by very low throughputs it must be said that from the very brief observation possible there is some doubt as to the correctness of the apportionment of fuels.

3.11 Cold Rolling Mill

Output has increased by 15% and the energy consumption has also increased overall by 6%.

The major portion of this increase in energy is reflected by the usage of nitrogen and synthesis gas which is unexplained.

Fuel consumption is very much related to throughput. With the increase in production a fuel saving of 7% is achieved. Two of the 48 hood annealers are commissioned with ceramic fibre lining giving an average saving of 10%. This is soon to follow on another 16 furnaces.

A saving in power of 2% is achieved due to higher output.

CRM boiler operation is very poor and this may reflect in the increase in oil used at the boiler. Steam quality is erratic and poor. With steam super heaters not working the boilers are operating at very low efficiency. Since the amount of oil used is very small little effort is expended in this area.

3.12 CRGO and NGO

The production rates seems to vary a lot year by year. The energy figures are mostly by allocation and where they are not, they must be suspect as so many meters were found not to be working.

For effective managerial control it is recommended that instrumentation should be brought to an acceptable level.

3.13 Steam Generation

The total steam generation from the 2 Power Plants and the medium pressure boilers has increased by 62%. The steam from the CRM boilers has not been included as it is very small and the energy usage is included in the CRM.

The data for the 3 boiler plants was available separately and is presented in Table 3.13.

The steam generated from the M.P. boilers has been decreasing steadily over the 3 years under consideration and was 28% lower in 89/90 than in the base year. The net energy had increased slightly by 12%, largely due to higher steam input.

At the old power plant (PP1) there had also been a decline in generation of 15% and again the net energy had increased by 13% largely due to higher fuel input.

The new power plant (PP2) was commissioned during 87/88 and output has steadily risen. The net energy consumption has decreased with each year until in the current year it was recorded as using a negative quantity of energy. Clearly this is impossible and demonstrates the unsatisfactory accounting methods as well as omissions such as condensate which are neither debited or credited. The energy contained in a ton of steam is assumed to be the same (0.77 Gcal/t steam) for all boilers whatever the steam conditions. This is clearly not so, but the data are comparative and as steam is charged out at the same energy level the overall energy balance is correct. The system is unsatisfactory (as at BSP as well) and should be changed.

The proportion of oil used has declined a little at PP1 from 15 to 14%. At PP2 it has fallen from 10 to 5%.

Total steam generation per ton of crude steel has increased from 3.26 to 5.12 tons/TCS (57%) but the amount of power generated has increased as well.

Subtracting the steam used for power production and turbo blowers gives a measure of the process steam used and this has declined by 21%. Expressed on a crude steel basis there has been an improvement of 24% from a level of 1.12 to 0.86 tons/TCS which reflects the real economies which have been achieved in this area.

3.14 Power Generation

The electrical output from PP1 has declined by 19% as PP2 has increased so that overall the electricity generated has gone up by 248%. At PP1 the net energy consumed has decreased by 31% due to lower steam usage. At PP2 the energy usage is negative, because the energy in steam is understated. It is however possible for this factor to be negative as electricity is valued at 3 Gcal/Gwh which represents the level achieved by a moderately efficient public utility. An efficient power plant could well beat this figure and record a negative energy usage. But it would be preferable to use the actual heat/ton steam so that a proper comparison can be made.

The power generated has increased from 270 to 917 kWh/TCS (237%) and more is now generated than is used by the steel plant. It is disappointing that the specific electricity used has increased from 680 to 826 kWh/TCS - or nearly 22% higher. Some of this will be due to the working up of the CRGO plant which has a high power usage. Although no detailed analysis has been made it is suggested that RSP should investigate the reasons for this adverse trend.

3.15 Miscellaneous and Losses

Although RSP has the lowest consumption in this category of all three works, it is disappointing to see that the overall losses have increased by 22%. Given that RSP has set up a regular monitoring team for identifying and rectifying the leakage in both steam and arising fuels it is difficult to understand that both steam and fuel losses have increased by 104 and 263%. These areas need to be further investigated.

One reason for increased steam losses could be poor quality of low pressure steam and the loss of condensate. Partly this could also mean that steam allocation to the process areas may not be true.

Improvement in power losses of 51% have been achieved through good housekeeping in this area.

Improvement in oxygen usage is more a matter of allocation.

3.16 Works Total

The overall improvement was 6.5%, but on a balanced basis the energy reduction was 11.3%. Whilst the other two works achieved greater savings, they were also able to show greater rises in production - particularly at BSP where significant plant additions had been made. At RSP output was only 3% higher than three years ago.

In Table 3.17 the contribution of the various departments is itemised and the effects of changes in production ratio are separated from the changes due to departmental efficiency. The totals already quoted on the main table are taken from the records as were the departmental data. However when adding all the departments to construct Table 3.17 discrepancies were revealed in that the total (actual) for 1986/87 was 12.354 Gcal/TCS and for 89/90 11.340. These are significantly different from the works totals and although checked as far as possible an explanation was not discovered. It is perhaps most likely to be due to some error made earlier, but it does indicate greater savings (8.2%) on the actual consumption than the works data. It is suggested that perhaps RSP might check their data.

Whichever is true Table 3.17 is based on the BSC derived figures.

It will be observed that savings due to departmental efficiency are 2.38 Gcal/TCS. Power production, boilers, coke, sinter and iron accounting for all the savings. It is disappointing that so many of the mills have deteriorated, and Miscellaneous and Losses has increased substantially.

Production ratio changes have given an adverse effect of 1.37 Gcal/TCS. A higher PR than 86/87 will give an adverse variance as with Power, Steam, Sinter, and Coke. If the ratio is lower a gain is produced as for blast furnaces and Plate mill.

Some of these ratios can be influenced by management, such as coke (coke rate and screening), sinter (choice of burden of BF) and iron (higher scrap usage). Others, such as the mills are controlled by product demand. It is unfortunate that a highly desirable improvement in mill yield will show an adverse variance due to the ratio being based on crude steel.

ROURKELA STEEL PLANT
ENERGY CONSUMPTION BY PROCESS (AND RELATED DATA)

TABLE 3.1 COKE OVENS				Apr 89 Feb 90	Difference 86/87 & 89/90	
	86/87	87/88	88/89	(89/90)	Gcal/T	%
Output kT/a(Gross Coke)	1205	1311	1320	1203		
				(1312)		+8.9
Heat Input						
Coal Gcal/TP	9.159	8.822	8.966	8.913	−0.246	−2.7
Under firing Gcal/TP	0.855	0.794	0.792	0.794	−0.061	−7.1
Power Gcal/TP	0.141	0.116	0.113	0.122	−0.019	−13.5
Steam Gcal/TP	0.19	0.144	0.144	0.157	−0.033	−17.4
Total Input Gcal/TP	10.345	9.878	10.107	9.986	−0.359	−3.5
Heat Output						
Coke Gcal/TP	6.08	6.131	6.17	6.166	+0.086	+1.4
Gas Gcal/TP	1.417	1.447	1.538	1.562	+0.145	+10.2
By-Products Gcal/TP	0.361	0.344	0.364	0.386	+0.025	+6.9
Total Output Gcal/TP	7.857	7.921	8.072	8.144	+0.287	+3.65
Net Usage Gcal/TP	2.488	1.957	1.945	1.875	−0.613	−24.6
Energy Yield Loss Gcal/TP	1.301	0.901	0.894	0.769	−0.532	−40.9
Energy Yield Loss % coal input	14.2	10.2	9.97	8.6		
Energy net of yield loss	1.187	1.056	1.051	1.106	−0.081	−6.8
Production Ratio	1.095	1.176	1.109	1.155		+5.5
Gcal/TCS	2.724	2.301	2.156	2.166	−0.558	−20.5
Yield - G.Coke/Coal	0.734	0.766	0.757	0.759		
Yield BF Coke/Gross Coke	0.837	0.827	0.833	0.832		
B.F Screenings %	8.6	7.5	7.3	6.3		
Nut Coke used in B.F %	3.1	1.4	0.6	(neg)		
Total Screen loss (excl. nuts) %	25.9	24.5	23.2	22.1		

ROURKELA STEEL PLANT
ENERGY CONSUMPTION BY PROCESS (AND RELATED DATA)

TABLE 3.2 SINTER PLANT				Apr 89 Feb 90	Difference 86/87 & 89/90	
	86/87	87/88	88/89	(89/90)	Gcal/T	%
Output kT/a	897.7	961.5	1055	1018.7		
				(1111.3)		+23.8
Coke Breeze Gcal/TP	0.683	0.567	0.487	0.386	-0.297	-43.5
Ignition Gas Gcal/TP	0.11	0.081	0.081	0.084	-0.026	-23.6
Power Gcal/TP	0.1[illegible]5	0.14	0.126	0.116	-0.019	-14.1
Total Gcal/TP	0.929	0.788	0.694	0.586	-0.342	-36.9
Production Ratio	0.816	0.863	0.886	0.979		
Energy/T Crude Steel Gcal	0.757	0.68	0.615	0.574	-0.183	-24.2
Coke Breeze kg/t	95.2	93	79	63.9		
Return Sinter, % Raw Mix	39.8	41.3	42.7	36.5		

TABLE 3.3
BLAST FURNACES

Output kT/a	1223	1212	1252	1124.9		
				(1227.2)		+0.3
Coke Gcal/TP	4.814	4.682	4.541	4.495	-0.319	-6.6
Stoves Gcal/TP	0.603	0.637	0.623	0.625	+0.022	+3.6
Blast Steam Gcal/TP	0.519	0.536	0.496	0.5	-0.019	-3.7
Process Steam Gcal/TP	0.136	0.125	0.119	0.101	-0.035	-25.7
Power Gcal/TP	0.083	0.071	0.09	0.084	+0.001	+1.2
Total Input Gcal/TP	6.155	6.051	5.869	5.805	-0.350	-5.7
B.F Gas Recovery Gcal/TP	1.748	1.623	1.589	1.51	-0.238	-13.6
Net Energy Usage Gcal/TP	4.407	4.428	4.28	4.295	-0.112	-2.5
Coke - Gas Gcal/TP	3.066	3.059	2.952	2.985	-0.081	-2.6
Production Ratio	1.112	1.087	1.052	1.081		
Energy/TCS, Gcal	4.901	4.813	4.503	4.643	-0.258	-5.3
Coke Rate, kg/t	792	764	736	729		
Raw Flux kg/t	125	121	113			
Metal Si %	1.58	1.6	1.6	(1.60)		
Blast Temperature Deg.C	730	737	717	699		

ROURKELA STEEL PLANT
ENERGY CONSUMPTION BY PROCESS (AND RELATED DATA)

TABLE 3.4 STEELMAKING – OH				Apr 89 Feb 90	Difference 86/87 & 89/90	
	86/87	87/88	88/89	(89/90)	Gcal/T	%
Output kT/a	198.2	201.1	219.1	216		
				(235.6)		+18.8
Fuel Gcal/TP	1.583	1.317	1.24	1.166	-0.417	-26.3
Power Gcal/TP	0.103	0.071	0.11	0.135	+0.032	+31.1
Steam Gcal/TP	0.221	0.237	0.218	0.191	-0.030	-13.6
2222	0.105	0.086	0.071	0.095	-0.010	-9.5
Total Gcal/TP	2.012	1.71	1.639	1.587	-0.425	-21.1
Production Ratio	0.18	0.18	0.184	0.207		
Energy/ton Crude Steel Gcal	0.362	0.308	0.302	0.329	-0.033	-9.1
Iron Charge kg/t	572	556	549	552		
Scrap kg/t	533	530	536	562		

TABLE 3.5
STEELMAKING – LD

Output kT/a	901.8	913.4	971.1	825.6		
				(900.6)		-0.1
Fuels Gcal/TP	0.26	0.286	0.284	0.296	+0.036	+13.8
Power Gcal/TP	0.124	0.123	0.127	0.157	+0.033	+26.6
Steam Gcal/TP	0.003	0.003	0.003	0.007	+0.004	+133.3
Oxygen (+N2) Gcal/TP	0.158	0.13	0.124	0.13	-0.028	-17.7
Total Gcal/TP	0.545	0.541	0.538	0.590	+0.045	+8.3
Production Ratio	0.820	0.820	0.816	0.793		
Energy/ton Crude Steel Gcal	0.447	0.444	0.439	0.468	+0.021	+4.7
Scrap kg/t	151	159	163	164		
Hot Metal kg/t	1051	1019	1011	1030		
Steel Melting Overall						
Output kT/a	1100	1114.5	1190.2	(1135.7)		+3.2
Gcal/TCS	0.809	0.752	0.741	0.797	-0.012	-1.5

ROURKELA STEEL PLANT
ENERGY CONSUMPTION BY PROCESS (AND RELATED DATA)

TABLE 3.6 PRIMARY MILL				Apr 89 Feb 90	Difference 86/87 & 89/90	
	86/87	87/88	88/89	(89/90)	Gcal/T	%
Output kT/a	938.6	972.3	1033.6	(1018.6)		+8.5
Fuel Gcal/TP	0.318	0.327	0.302	0.29	-0.028	-8.3
Power Gcal/TP	0.106	0.105	0.104	0.102	-0.004	-3.8
Oxygen Gcal/TP	0.014	0.012	0.012	(0.012)	-0.002	-14.3
Total Gcal/TP	0.438	0.444	0.418	0.404	-0.034	-7.8
Production Ratio	0.853	0.872	0.868	0.897		
Energy/ton Crude Steel Gcal	0.374	0.387	0.363	0.362	-0.012	-3.2
Cold Charge %	19.9	22.7	19			
Track times < 3.5 hr %	48.9	57	66.6			
Heating time hr-min	11-01	10-17	8-56			

TABLE 3.7
PLATE MILL

Production kT/a	262.1	239.1	254.2	(245.9)		-6.2
Fuel Gcal/TP	0.704	0.856	0.863	0.928	+0.224	+31.8
Power Gcal/TP	0.361	0.397	0.379	0.374	+0.013	+3.6
Total Gcal/TP	1.065	1.253	1.242	1.302	+0.237	+22.3
Production Ratio	0.238	0.215	0.214	0.2165		
Energy/ton Crude Steel Gcal	0.253	0.269	0.266	0.282	+0.029	+11.5

TABLE 3.8
HOT STRIP MILL

Production kT/a	642.5	704	804.8	(776.7)		+20.9
Fuel Gcal/TP	0.574	0.572	0.52	0.552	-0.022	-3.8
Power Gcal/TP	0.41	0.411	0.405	0.42	+0.010	+2.4
Total Gcal/TP	0.984	0.983	0.925	0.972	-0.012	-1.2
Production Ratio	0.584	0.632	0.676	0.684		
Energy/TCS Gcal	0.575	0.621	0.625	0.665	+0.090	+15.7

TABLE 3.9
PIPE PLANT (SPIRAL)

Output kT/a	62.4	79.2	85.6	(78.8)		+26
Power/Total	0.305	0.305	0.398	0.474	+0.169	+55.4
Production Ratio	0.057	0.071	0.072	0.069		
Energy/TCS Gcal	0.017	0.022	0.029	0.033	+0.016	+94.1

ROURKELA STEEL PLANT
ENERGY CONSUMPTION BY PROCESS (AND RELATED DATA)

TABLE 3.10 ELECTRIC SHEET MILL	86/87	87/88	88/89	Apr 89 Feb 90 (89/90)	Difference 86/87 & 89/90 Gcal/T	%
Output kT/a	16	18.15	19.66	(15.54)		-2.9
Fuel Gcal/TP	2.755	2.602	2.489	3.379	+0.624	+22.6
Power Gcal/TP	0.92	1.11	1.101	1.07	+0.15	+16.3
Steam Gcal/TP	0.811	0.747	0.643	0.887	+0.076	+9.5
Oxygen/N2/S.G, Gcal/TP	0.081	0.154	0.103	0.074	-0.007	-8.6
Total	4.567	4.613	4.337	5.41	+0.843	+18.5
Production Ratio	0.0145	0.0163	0.0165	0.0137		
Energy/Ton Crude Steel Gcal	0.066	0.075	0.072	0.074	+0.008	+12.1

TABLE 3.11
COLD ROLLING MILL

Output kT/a	342.5	411.6	437.4	(394.9)		+15.3
Fuel (COG) Gcal/TP	0.769	0.693	0.651	0.717	-0.052	-6.8
Boiler Oil Gcal/TP	0.053	0.061	0.026	0.056	+0.003	+5.7
Power Gcal/T.P	0.736	0.826	0.809	0.723	-0.013	-1.8
N2/S.G, Gcal/TP*	0.131	0.191	0.248	0.289	+0.158	+120.6
Total	1.689	1.772	1.736	1.788	+0.099	+5.9
Production Ratio	0.311	0.369	0.368	0.348		
Energy/Ton Crude Steel Gcal	0.525	0.654	0.639	0.622	+0.097	+18.5

TABLE 3.12
CRGO (& NGO)

Production kT/a	7.35	18.01	74.2	(21.3)		+189.8
Fuel Gcal/TP	0.833	0.975	0.763	1.473	+0.640	+76.8
Power Gcal/TP	6.014	3.777	4.603	5.472	-0.542	-9.0
Steam Gcal/TP	0.611	0.376	0.279	0.402	-0.209	-34.2
Syn. Gas Gcal/TP	(0.132)	0.128	0.132	0.137	(+0.005)	(+3.8)
Total	7.590	5.255	5.777	7.484	-0.106	-1.4
Production Ratio	0.0067	0.0162	0 0203	0.0188		
Energy/Ton Crude Steel Gcal	0.051	0.085	0.117	0.141	+0.090	+175.9

* S.G. = Synthesis Gas

ROURKELA STEEL PLANT
ENERGY CONSUMPTION BY PROCESS (AND RELATED DATA)

TABLE 3.13 STEAM GENERATION				Apr 89 Feb 90	Difference 86/87 & 89/90	
	86/87	87/88	88/89	(89/90)	Gcal/T	%
M.P. BOILERS						
Output kT/a	747	617	600	(536)		−28.2
Fuel Gcal/TP	NR	0.802	0.900	0.810	(+0.008)	(+1.0)
Steam input Gcal/TP	NR	0.142	0.149	0.160	(+0.018)	(+12.7)
Steam output Gcal/TP	NR	0.770	0.770	0.770		
Net Energy Gcal/TP	NR	0.175	0.279	0.196	+0.021	+12.0
Production Ratio		0.554	0.504	0.472		
Energy/TCS Gcal		0.097	0.141	0.093	−0.004	−4.1
Notional Efficiency		81.5	73.4	79.7		
POWER PLANT 1 – BOILERS						
Output kT/a	2835	2455	2659	(2412)	-	−14.9
Fuel Gcal/TP	0.763	0.765	0.794	0.782	+0.019	+2.5
Power Gcal/TP	0.094	0.097	0.092	0.092	−0.002	−2.1
Steam input Gcal/TP	0.093	0.092	0.101	0.099	+0.006	+6.5
Steam output Gcal/TP	0.77	0.77	0.77	0.77	-	-
Net Energy	0.18	0.184	0.217	0.203	+0.023	+12.8
Production Ratio	2.577	2.203	2.234	2.124	-	-
Gcal/TCS	0.464	0.405	0.485	0.431	−0.032	−7.1
Proportion of oil used %	4.9	14.2	12.9	13.9		
Notional Efficiency %	81.1	80.1	77.9	79.1		
POWER PLANT 2 – BOILERS						
Output kT/a	0	1276	2502	(2865)	-	-
Fuel Gcal/TP		0.61	0.68	0.614	−0.196	−24.2
Electricity Gcal/TP		0.132	0.122	0.103	−0.029	−22.0
Steam Input Gcal/TP		NR	0.018	0.046	+0.046	
Steam Output Gcal/TP		0.77	0.77	0.77		
Net Energy Gcal/TP		0.172	0.65	−0.007	−0.179	−104
Production Ratio	0	1.145	2.102	2.522		
Energy/ton crude steel,Gcal	0	0.197	0.105	−0.018	−0.215	−109
Proportion of oil used %	0	10.1	5.4	5.4		
Notional Efficiency %		81.7	93.9	100.9		
STEAM USAGE						
Total Steam kT/a	3.582	1.348	5.761	(5.813)		+62.3
Steam/Ton Crude steel	3.256	3.901	4.84	5.118		+57.2
Steam for Power and TB's T/a	2349	3271	4588	(4841)		
Process Steam & Losses by difference (ex CRM) T/a	1233	1077	1173	(972)		−21.2
Process Steam/T Crude Steel, T	1.121	0.966	0.986	0.858		−23.7
TOTAL ENERGY FOR BOILERS						
Per ton Crude Steel, Gcal	0.6	0.699	0.731	[illegible]	[illegible]	−15.7

ROURKELA STEEL PLANT

ENERGY CONSUMPTION BY PROCESS (AND RELATED DATA)

TABLE 3.14 POWER GENERATION	86/87	87/88	88/89	Apr 89 Feb 90 (89/90)	Difference 86/87 & 89/90 Gcal/T	%
POWER PLANT NO.1						
Output Gwh/a	299.5	270.4	275.5	(242.9)		-18.9
Steam input Gcal/Gwh	3.919	4.027	3.735	3.634	-0.285	-7.3
Power Output Gcal/Gwh	3	3	3	3		
Net usage Gcal/Gwh	0.919	1.027	0.735	0.634	-0.285	-31.0
Prod. Ratio Gwh/TCS	0.272	0.198	0.231	0.214		
Energy/ton Crude Steel Gcal	0.25	0.203	0.17	0.136	-0.114	-45.6
Notional Efficiency %	21.9	21.4	23	23.7		
POWER PLANT NO.2						
Output GwH/a		341.3	684.4	(798)		
Steam Input Gcal/Gwh		2.879	2.751	2.698	-0.181	-6.3
Power Output Gcal/Gwh		3	3	3		
Net Usage Gcal/Gwh		-0.121	-0.249	-0.302	-0.181	
Production Ratio Gwh/TCS		0.306	0.575	0.703		+130
Energy/Ton crude Steel		-0.037	-0.143	-0.212	-0.175	
Notional Efficiency %		29.9	31.3	31.9		
TOTAL POWER						
Production Gwh/a	299.5	561.7	959.9	(1040.9)		+248
Energy/TCS	0.25	0.082	0.027	-0.076	-0.326	
Power Generated/TCS,Kwh	272	504	807	917		+237
Power Consumed/TCS,Kwh	680	753	793	826		+21.5

TABLE 3.15

AUXILLIARIES AND LOSSES

Fuel Gcal/TCS	0.183	0.116	0.175	0.373	+0.190	+104
Power Gcal/TCS	0.164	0.169	0.267	0.08	-0.084	-51.2
Steam Gcal/TCS	0.008	0.046	0.043	0.029	+0.021	+263
02 and N2, Gcal/TCS	0.098	0.085	0.087	0.069	-0.029	-29.6
TotalGcal/TCS	0.453	0.416	0.572	0.551	+0.098	+21.6

TABLE 3.16

WORKS TOTAL

Crude Steel Output	1100	1114.5	1190.2	(1135.7)		+3.2
Gcal/TCS actual	12.19	12.037	11.493	11.397	-0.793	-6.5
Gcal/TCS Balanced	11.651	11	10.632	10.33	-1.321	-11.3

TABLE 3.17

ROURKELA STEEL PLANT ANALYSIS OF DEPARTMENTAL CHANGES			
COMPARISON OF 86/87 AND 89/90	CHANGES/TON CRUDE STEEL		
DEPARTMENT	DUE TO EFFICIENCY Gcal/TCS	DUE TO PROD.RATIO Gcal/TCS	TOTAL Gcal/TCS
Coke Ovens	0.708	(0.150)	0.558
Sinter Plant	0.335	(0.152)	0.183
Blast Furnaces	0.121	0.137	0.258
OH Furnaces	0.087	(0.054)	0.033
LD Furnaces	(0.036)*	0.015	(0.021)
Slab Mill	0.031	(0.019)	0.012
Plate Mill	(0.051)	0.022	(0.029)
Hot Strip Mill	0.008	(0.098)	(0.090)
Pipe Mill	(0.012)	(0.004)	(0.016)
Electric Steel Mill	(0.011)	0.003	(0.008)
Cold Rolling Mill	(0.034)	(0.063)	(0.097)
CRGO Mill	0.002	(0.092)	(0.090)
Boilers	0.415	(0.321)	0.094
Power Production	0.919	(0.593)	0.326
Miscellaneous and Losses	(0.098)	-	(0.098)
TOTAL	2.384	(1.369)	1.015

* FIGS. IN BRACKETS ARE ADVERSE CHANGES

PART 4

ENERGY MONITORING STUDY

BOKARO STEELWORKS (BSL)

ENERGY MONITORING - BSL

CONTENTS

TABLES

4.0 ASSESSMENT REPORT ON BOKARO STEEL WORKS (BSL)

4.1 Coke Ovens

Although output increased up to 88/89 by some 7%, there had been operating problems in the current year so that output rate was only 1% more than in the base year. The problems were due to high labour turnover together with a recruitment ban. Consequently machine maintenance had suffered and at times agreed shift manning could not be achieved so that the requisite number of pushes were not being obtained.

Nevertheless the net energy usage had continued to decline, and in the current year was almost 30% lower than in 1986/87. Of the overall saving of 0.512 Gcal/t gross coke no less than 0.479 (94%) was due to a large improvement in the 'energy yield loss' which is the heat in the coal charged less the heat in the coke, gas and by-products produced. As the gas and by-product yield on a heat basis was down by only 0.067 Gcal/TP the effect is clearly related to improved yield of coke from coal. This is demonstrated by the normally reported yield increasing from 0.77 (which used to be a fixed assumption) up to 0.806. This will account for most of the improvement, although favourable calorific value changes of coal and coke must also have contributed.

The 'energy yield loss' has decreased from 0.778 to 0.299 Gcal/TP and from 8.9% to 3.6% of the heat in coal charged, most of the improvement being within the current year. Indeed in the single month of February the loss was down to less than 2%, and is now approaching World standards.

A good deal of effort was devoted to finding the reasons for this improvement with only limited success. The main reason was said to be due to better accounting for charged coal, and indeed this is supported by the data. The improvement in the heat in coke must be because of higher calorific value due to increasing proportion of imported coal, as there had been no change in the method of coke accounting which still relied on blast furnace weights and sampled breeze weights.

A policy had been adopted of weighing all coal wagons and there was now good agreement between these weights, on which payments were made, and the weights of coal charged. Accounting assumptions of tons/oven had been changed on the basis of coke stock reappraisals made when coke stocks had been depleted (i.e. coke stocks were higher than had been assumed).

The suggestion that a special exercise should be mounted to reveal the truth of the situation had not been carried out. Whilst it is not an easy exercise, it could be revealing. Perhaps R&D should tackle this for all SAIL plants.

It is planned to install weighers on the coke conveyors and the breeze conveyors from the blast furnaces. There was no mention of making better use of the charge car weighers under the coal towers and these should be used and recalibrated and changed to load cells if this is necessary.

There was also a useful improvement of 4% in under firing gas for which there was no specific explanation except better attention to detail.

Power consumption although 10% higher had little influence on overall energy and was perhaps due to the fact that a benzole extraction plant has been added since '87.

Process steam was down by 10% despite benzole extraction requiring more steam.

Gas yield was down by 4.5% presumably due to changes in the coal volatile matter - but this should be checked to make sure that it is not an indicator of oven deterioration. Hydrojet cleaning had been introduced for oven doors which would offer reduced losses

By-product yield was slightly higher than in 86/87, perhaps due to benzole now being extracted and recorded.

Leaving the 'yield loss' improvement on one side there was still a 3% improvement mainly due to the under firing economies.

Pushing was irregular during the last visit and although no quantified indices were presented the impression was gained that it is still poor particularly under the current labour shortage situation.

The most worrying feature was that the screenings (-25mm at the coke ovens) had deteriorated significantly from 12.8% in 86/87 to 16.5% in 89/90. It must be emphasised that these comparisons are unreliable due to the many assumptions and estimates made in the accounting procedures. Indeed it is possible to visualise such changes having an influence on the improved coal to gross coke yield. If the main pivot of the coke estimate is skip weight and the estimates (real or imaginary) show an increase of screenings, the gross coke yield will apparently increase. The only explanation from the plant was that the coke crushing plant had been tightened up to reduce the +80mm in the BF coke and had therefore generated more fines.

As well as this the screenings at the blast furnaces had also increased from 7.7% to 9.6% at least partly due to the fitting of improved coke screens. The overall effect of all this is to reduce the yield of skip coke from gross coke from 80.5% to 5.5% which is the worst of the three plants studied (eg Bhilai - [illegible]%).

It is clearly necessary to check the weighing and accounting procedures and compare notes with Bhilai where the coke sorting plant is very similar, except that a screen aperture of 20mm has been adopted there. Perhaps such a change could be made at Bokaro now the furnaces have better screens and this should be considered, as well as the possibility of relaxing the top size specification.

The point of this argument is that a large screen loss will affect the production ratio (coke oven output/crude steel) and increase overall energy usage. In the event the production ratio has moved favourably due to less export and coke stocking so that the coke energy is 45% less per ton of crude steel than 3 years ago, but the result would have been better with lower screenings.

Overall this represents very satisfactory progress to levels approaching good world practice except for the very high screening loss where action should be taken as above and outlined in the first report.

4.2 Sinter Plant

The output is about 11% higher than in 86/87 but has been fairly static for the last 3 years.

Energy consumption is lower by nearly 13% largely due to a 15% saving in breeze consumption. The explanation of the latter was that maintenance of the coke crushing equipment was improved so that the +3mm was now down to 15%, which is still rather on the high side. It is planned to install a double deck 25 and 3mm screen ahead of the crushers in order to reject the over size and by-pass the crusher with the under size. It was pointed out that blinding problems would be experienced on the 3mm screen unless special measures were applied; such as heated or flexible screen mats.

Also the sinter bed heights had been increased from 350mm to 380mm, with the No.2 strand, recently refurbished, operating at 400mm. This would also reduce the breeze rate. Bed heights had been increased by improving suction to 900/950mm wg as a result of more attention to reducing leaks in the pallets and the suction system, and by fitting spring loaded bars in the wind boxes.

Three years ago it was suggested that the coke rich upper layer (150mm) should be thinned and it was claimed that this had been done. On the 380mm beds, the coke rich part was 140mm and on the 400mm bed it was 160mm. This change is only marginal but should help a little. The original proposal envisaged a more drastic change to say 100mm or less and this should still be considered and trials carried out to determine the optimum top layer thickness and differential coke content.

Ignition gas has been reduced by 13% which would be accounted for by the deeper beds and higher output. However it appears that little has been gained on combustion control. The windlegs under the hood have been throttled and the number of burners in operation in the second zone have been reduced. The hood height has also been reduced by 400mm. Despite these changes the gas consumption is still high by international standards and the highest of the three SAIL plants under examination. There should be scope for more savings by better control and it is suggested that the second zone should be unfired or better still removed altogether.

Power was down by 8.0%, partly due to better output and partly due to a policy of progressively closing the main dampers during stoppages and switching off for long stops.

Return sinter levels have been reduced from 40 to 32% as a reflection of the deeper beds and better operation as well as changing the screening philosophy.

The hot screens have been plated over and this has been successful except for dust arising from the up draught sinter coolers, so that it is intended to replace the blanks with 5mm mats in one strand in the near future. It was suggested that they might consider the feasibility of extending the dust extraction hoods over the coolers.

Screening is still not properly rationalised as apertures are too large on the cold screens (8mm and 12mm). This is a single deck screen with 2 collecting hoppers for -8mm (returns) and 8-12mm (hearth layer) with the nominally +12mm going forward to the blast furnaces. As the hearth layer is not in use the 8-12mm fraction also joins the return fines. This should be changed by sending this fraction forward to the furnaces. Better still install a full 5 or 6mm screen until the hearth layer is required again and so only return -5/6mm to the plant. It is disappointing that this proposal has not been initiated before now.

Sinter screens at the furnaces have not been substantially changed but the electro magnetic drives have been changed for more efficient mechanical vibrators and punched mats are also on trial. The amount of sinter extracted is not known and is assumed to be a constant 10%. There is a plan to install a belt weigher which will at least give the overall level of sinter return from the blast furnaces.

Three years ago there was a serious problem in crushing enough limestone and in crushing quality. This has been eased by obtaining a source of softer, lower silica lime stone and the +3mm is now around 15%. The sinter/THM is in fact a little lower but the raw flux has been reduced as the sinter basicity has been increased. Most of the time only 2 strands have been operated as specific output has increased but blast furnace demand has been fairly static.

The sinter surge bunker and the improvements in automating water additions and coke proportioning have still nct been installed.

Higher chrome grate bars were unsuccessfully tried as they tended to break. Trials are now in hand with 25 carbon forged steel bars. As bars are still a problem it is surprising that the hearth layer is not in use. It was claimed that mechanical modification is needed before this can be done.

An interesting development concerns the strand cooling system. There are 3 windboxes served by a separate fan for on-strand cooling. On one strand the ductwork has been modified so that these are now connected to the main fan. This gives a larger sintering area and potentially higher output. Strand suction will be decreased somewhat but there should be an overall advantage as long as the main sinter coolers can cope - particularly with the hot screens plated over. It is expected that this will be carefully assessed with a view to extension to the other 2 strands.

In summary a great deal has been done (with some omissions) and although useful savings have been made, perhaps more could have been expected. Further progress on the lines already established should give even better results in future.

4.3 Blast Furnaces

Output has increased by 14%, although levels in the current year are a little lower than in the two previous years.

Net energy consumption is lower by 5%. Although this may seem modest the total energy consumed on blast furnaces is so high that a relatively small percentage saving is important and represents in this case a very useful 0.2 Gcal/T product. Energy was even lower in 88/89.

The coke saving of 2.5% (again worse than the previous two years) accounts for about half the overall reduction although the decreased gas make offsets 85% of this saving.

The coke rate reductions have been achieved despite a reduction of blast temperature of about 50°C. It would be explainable if the blast humidity had been reduced but the statistics indicated a 50% increase between '87 and '89. This does not tally with the reduction in process steam usage which was reported, and as there have been changes in allocation it is difficult to be certain what has really happened; but steam injection has probably been reduced. Other important factors are that silicon in hot metal is down by around 0.5% and that raw fluxes fell from 43kg/THM in 86/87 to 25kg/THM i[illegible]/89.

Stove gas fell by 11%. The majority of this can be explained by lower coke rate (and hence blast/THM) and the lower blast temperature. The cold blast mains have now all been insulated. These three factors will roughly explain the savings made indicating that there has been little or no improvement in stove operation or hot blast leakage. Except on the recently refurbished No.4 furnace, the others are operated manually as 3 years ago. Comparisons should be made between No.4 furnace with new auto controls and the older ones. Many suggestions were made three years ago on how stove operation could be improved. Only one had been adopted, and unenriched BF gas is now used. This will release coke oven gas for other parts of the works and could have some control advantages as dome temperatures can be regulated with less excess air. A major proposal in the original report was to operate only 3 of the 4 stoves on each furnace. This is done when a stove is off for maintenance with no adverse affects on blast temperature. Although no argument was advanced against the proposal it has not been adopted.

The inference from the data is that hot blast leakage has not improved significantly. Bellows type tuyure stock have been fitted on one furnace only. However the operators are not happy as blast leaks are still apparent. A change in design or application of the tuyure stock may be the answer as this type of system gives good results elsewhere. Despite these criticisms and the clear indication that consumption is still excessive this is the only one of the three plants that has recorded savings in this area.

Blowing steam has been reduced by 14.5%. This is attributed to the fact that the variable speed controls in the blower house are now used in normal operation. When walking past the line of furnaces on one occasion, the snort valves were open on at least 3 of the 5 furnaces. One problem is that the blowers are optimistically sized giving poor 'turn down'. It was suggested that the turbo blower manufacturers should be consulted to see whether the machines could be modified to a lower capacity perhaps by the removal of a stage.

Process steam is down by 36%, perhaps due to refining the allocation procedures. This certainly contradicts the evidence of the statistics book and supports the view that steam injection has been reduced. The proposal to use nitrogen for sealing and purging has not materialised. Capital costs were higher than initially expected but it was not clear whether the scheme was uneconomic or simply not of high priority.

The savings in these three peripheral areas (stoves, blowing and process steam) account for the total economies made of 0.2 Gcal/THM.

Power usage was the only category where an increase was registered mostly in the current year. No explanation was offered for the 25% increase that offsets the saving in 'coke minus gas'.

No.4 furnace has been rebuilt with a bell-less top and a modern new control room. It was stated that output was 10% better and coke rate 50 kg/t lower but others were sceptical of these estimates. It is also proposed to add a recuperator to preheat the stove combustion air and it is claimed that a 4 year pay back will be obtained.

A good deal of money has been spent on sophisticated technology when the first call on capital should be the improvement of the quality and consistency of burden materials, for example bed blending the sinter plant feed. Actions have been taken in that coke screens have been replaced by double deck 50 x 25mm screens which had reduced the -25mm to the furnaces and the +25mm to the coke fines. Sinter screens had also been improved and there were ideas for doubling the screening area.

The suggestion of trying a wider coke size range to improve the skip coke/gross coke ratio was not sympathetically received on the basis of poor operation when size range was accidentally enlarged due to equipment breakdown. Nevertheless the difference between

BSP and BSL should be investigated where the former use 20mm screens and have a much higher skip coke/gross coke yield.

Three years ago many tuyeres were closed which led to a suggestion to install smaller diameter tuyeres. This has not been done. Tap hole tuyeres have been reduced but others enlarged. But as the numbers closed is now down to 2 per furnace, this matter was not pursued.

Water-less tap hole clay has been tried, the object being to keep the tap hole tuyeres fully open and of full diameter. The clay guns were not powerful enough.

Casting discipline was said to be slightly better due to better trough materials.

In summary the department has shown encouraging results although much scope still exists.

4.4 LD Steel Plants

Output has increased by no less than 27% although the current year is a little lower than 88/89.

Although energy usage in the department is not high it is disappointing to record an increase of 1.4% despite the higher output and the fact that partial LD gas recovery is now in operation.

This is due to two factors. Oxygen energy has increased by 38%, although the volume of oxygen used has only increased by 3%. The rise is largely because the energy charged for 100m^3 of oxygen has risen from 2800 Kcal in 86/87 to 3740 in 89/90 to date (in February '90 it was nearly 4000 Kcal) based on actual data; which is very high. The energy used at the oxygen plant is assessed monthly and this figure is used in the statistics. This is a totally different procedure from that at the other 2 works where the energy in oxygen is assumed to be constant, and changes in the efficiency of production are presumably absorbed in "miscellaneous and losses". Proposals for a uniform approach at all SAIL plants are made in Part 1 of this report. Excessive energy used for oxygen production should be charged to the Oxygen plant rather than to the LD plant.

The other factor was that steam recovery was down by 25% which reflects a deterioration of the waste heat boilers on the older plant. But as the system of estimating the steam make was altered it was impossible to quantify this effect.

Fuel usage was down by 22%. The reasons had not been quantified but it would be influenced by greater output and the adoption of sliding gates. It was also stated that C.O gas pressures were down because of blocked mains and this had imposed an unwanted economy at the mixers where metal temperatures had suffered.

Steam was lower by 7% but allocations had changed. Power was reduced by 8%, largely due to higher output.

A major disappointment was that BOS gas recovery has made slow progress only starting in 88/89. The recovery during 89/90 reached 0.026 Gcal/TCS or approximately 0.05 Gcal/ton produced in the shop fitted with recovery equipment. This is about half of the planned yield. This is because gas is recovered from only 70% of the heats due to a fault in equipment (which should soon be rectified as spares are now available). Of the gas recovered only two thirds was used by mixing it with coke oven gas. It is expected that recovery will be doubled during the coming year and as experience is gained it should be possible to increase the gas collection per blow by some 25 - 30%.

Nothing has been done to improve the burners on the mixers or ladle heaters which was recommended 3 years ago.

The major contribution that can be made by an LD steel plant towards reduced plant energy is by reducing the hot metal consumption and so saving the energy needed for iron making.

Although there were minor reductions in hot metal in the first two years under review the rate had increased in 89/90 from 955 to 1014 kg/TCS.

The point was made was that the figures presented are the gross or the blast furnace department figures, and that the net weight at the melting shop was lower and that the differences had increased as follows:

1986/87 - Gross 955 kg/t, Net 925 kg/t, Difference 30 kg
Feb.'90 - Gross 1020 kg/t, Net 960 kg/t, Difference 60 kg

In other words the so called "Mixer loss" had increased from 3.2% to 5.9%.

It is difficult to envisage a loss of 30 kg/TCS and a loss of 60 kg would be incredible. A special survey had been carried out by BSL. The results were perhaps predictable. In note form: weighing at both BF and SP highly suspect, sometimes estimated, sometimes taken 'on the run' and so on; slag on iron; build up on ladle lips and mixer mouths preventing full emptying; return tares not taken etc. The recommendation was to install new electronic weighbridges designed for use'on the run'.

As well as this feature it was pointed out that (a) silicon in hot metal was down from 1.5 to 1.0% (b) manganese down by 0.1%, (c) poor lime quality (Cao down from 80% to 74%), (d) hot metal temperatures down by an unspecified amount.

Whilst (a) and (b) would be welcome changes offering overall advantages, (c) should be capable of improvement. The reduction in hot metal temperature could not be quantified but the following for October 1989 demonstrate the basic problem.

	SMS 1	SMS 2	NORM
Hot metal track time - min	94	97	75
Ladle emptying time - min	124	83	55
Ladle turnround time - min	229	194	140

Whether these are higher than previous practice is not clear, but improvements would clearly be beneficial and reduce the hot metal ratio. Such delays arise from: poor casting discipline at the Blast Furnaces causing ladle bunching; inefficient traffic operations; stoppages at the melting shops causing mixers to be full (and in passing a possibility of incorrect mixer operation); breakdown of locomotives and mixer cranes etc. These situations often result in too many iron ladles being in circuit which can exacerbate the problem by causing ladle skulling and ladle lip build up. Attention to detail in all these areas is the first priority but insulating material on the top of the iron and/or ladle lids can help. These points were made in the first report but action has not been taken on insulation or ladle lids.

4.5 Primary Rolling

The output has increased by 35% with a creditable decrease in overall energy consumption of 18% over the three year period.

Fuel gas utilisation was improved by some 15% and steam was only one ninth of the base level. However steam allocations have been changed and this is unlikely to be a true saving.

The fuel savings are partially due to improved productivity and partly through improved plant and operation. The lid design and sealing system and the pit support structure have been modified. Eight of the pits now have microprocessor controls.

Monitoring procedures have been established to improve scheduling and hence raise productivity. But track times have been reduced only marginally (6 hour 8 minutes to 5 hours 52 minutes) despite improved crane availability, an extra loco, and lower sticker ingots.

However, improvements are still needed in a further reduction of stickers and improved scheduling. Due to the varying sizes of ingots (300t from SMS II and 150t from SMS I) scheduling is still a problem. Efforts are being made to reduce the charging time from 55 min to 30 min by increasing the mould size at SMS I.

The main thrust of a programme of improvement must still include reducing track-time significantly. BSL in a feasibility study have shown that a new system of managing and scheduling can cut track time to 4 hours 35 minutes.

BSL Management recognise that the number of pits could be decreased as per BSC recommendations but this has not been done because of gas CV variability and non steady operation of the stripper yard. Management action is needed to reduce the number of pits in operation which can offer substantial savings.

Statistics show that cold charge has decreased from 29% to a present 22%. This is largely due to the fact that BSL held a very high stock which is presently dropped to 38% of its original level (30,000t). It is forecast that cold charging will be brought down to 15% which will facilitate the reduction in pit numbers and give further energy savings.

An improvement in power consumption of 13% is achieved mainly through improved rolling rates.

4.6 Hot Strip Mill

The output is increased by a massive 43% over the last three years.

The fuel usage in the furnace improved by 18%. This is mainly through the higher output but improved insulation of the skids and furnace will have contributed. In addition the door repairs are lasting longer reducing the downtime and giving increased production potential.

At the time of the visit one of the reheating furnaces was down for repairs and hence two furnace operation was being practised. With deployment of manpower from the third furnace, the hot charging was increased, on average to 11% and as high as 40% at times. This suggests that two furnace operation should continue and will offer a reduction in energy usage and an increase in production through increased hot charging.

Plans have been approved to rebuild one furnace with a new recuperator and incorporating micro-processor control which will further improve the plant performance.

An improvement in power consumption of 13% is achieved mainly through improved rolling rates. Steam usage is down by some 62% but this is perhaps partly due to changed allocations.

Steam recovery has decreased by as much as 41%. This is mainly due to improved skid insulation but also because of increased skid pipe leakages and hence reduced availability. Although skid insulation has improved the quality of the insulation is still poor and a high number of stoppages are still expected.

During the earlier study it was recommended that tonnage zone temperatures (1200°C) should be reduced. Management at present still use high temperatures for ease of operation. Through the implementation of delay strategy a 20°C temperature drop can offer substantial energy savings. An alternative to two furnace operation would be to use all three but with reduced preheat and tonnage zone temperatures.

No effort has been expended in reducing water pumping costs through improved usage of pumps. Again action is needed in this direction.

4.7 Cold Rolling Mill

The production rate has almost doubled (92%) in the last three years with an overall energy saving of 37%.

The fuel usage has improved by 31%. This is mainly achieved by converting 5 batch annealing furnaces to ceramic fibre linings. Actions are afoot to convert the rest. Plans are in hand to improve the charge weight from 45T to 70T in 1990/91. (currently running at 52T). However to achieve these high charge weights problems are being experienced in strip breakages due to an old welding machine. In future plans, annealing furnace automation is expected to yield energy improvements of 6 to 9%. Recuperation is not to be considered at this stage.

In the pickling line direct steam injection seems to continue. However plans are afoot to change this to indirect heating, as recommended, once the awaited pumps arrive (heat exchangers are available). It is hoped that the first phase of commissioning will take place in May 1990 with the rest to be completed in December, 1990.

Insulation of steam lines is improved. However, the quality and consistency of steam available from the SMS waste heat boilers and skid cooling is very poor. Management seems to be thinking of installing a package boiler. This should be avoided at all costs and effort should be spent to improve the steam availability from waste heat systems.

4.8 Steam Generation and Usage

There was a massive increase in steam generation of 33% attributable to the new captive power plant introduced during the relevant period. The use of fuel, steam and power were all less with steam down by 28%. Net usage of energy/ton steam was reduced by a massive 45% although these data are always suspect due to being the small difference between two large numbers (input energy and steam energy).

The total high pressure steam generated per ton crude steel was only 4% higher despite the steam usage for power production and blast furnace blowers being considerable higher.

Waste heat steam make was down by 15% despite higher production rates which implies some deterioration in the boilers or plant conditions. However further discussions showed that waste heat steam generation was an allocated figure.

The process steam is defined as the total HP steam plus waste heat steam less the net steam used for power production and less the steam for BF blowing. The steam for driving the air compressors should also have been subtracted but this data was not extracted from the statistics and so the derived process steam is not comparable with the other plants. The specific usage of process steam has been reduced by a very creditable 23%.

The proportion of 100 ata steam reduced to 39 ata has also reduced (see Table 4.8) as has the steam reduced to 8 ata.

However problems still persist in the thermal Power Plant (TPP) which is having difficulty in meeting the demand for process steam which is currently being imported from the new Captive Power Plant (CPP). The problem areas are still the same, i.e. (a) boilers designed to operate on mixed fuels (25% gaseous and 75% p.f.) are starved of gaseous fuel and are being supplemented by expensive oil (8.5% of the total fuel used). The balance of energy is provided by coal (84%) and arising gases. In addition the coal mills are incapable of meeting the boiler demand, thus boilers designed to operate at 220t/h are presently operating at 150t/h; (b) part load operation; (c) steam recovery from waste heat systems is poor; (d) the back pressure set is awaiting capital repair before it can be fully utilised to provide process steam; (e) grid situation is poor with wild frequency changes (more than 200 isolations in the coal mill areas this year)

Statistics show steam losses of 4.40% in 1987/88 increasing to 7.1% in 1988/89, and 6.6% in 1989/90. Due to changes in audit calculations in 1988 (i.e. meter corrections), it was pointed out that the 1987/88 figures cannot be used for comparison purposes. The increased losses from 1988 to 1989 can be explained in two ways:

1) during commissioning of the CPP increased steam losses occurred
2) due to lack of steam meters, some losses are allocated.

However substantial savings are achieved in the high pressure steam lines through improved insulation, reduced leakages (on line contract maintenance) and reduced throttling of high pressure steam to process steam (15.2% in 1987/88 to 9.3% in 1989/90).

4.9 Power Generation

Power generation has increased by 89% due to the new power station commissioned in 88/89. As the new station has no facilities for pass-out steam the amount per unit of electricity has decreased by nearly 50%. The overall net energy has reduced by 4%.

The specific electricity consumption has come down from 660 kWh/TCS in 86/87 to 539 kWh/TCS in 88/89, that is by 18%. The data for 89/90 were not readily available at the time of the visit.

4.10 Miscellaneous and Losses

All categories except oxygen have reduced so that overall the energy usage is 20% lower. Oxygen losses have increased to 22.4% which is higher than is desirable. LP steam losses are nearly doubled. This may be due to the revised allocation system.

4.10.1 Oxygen

An additional ASU is now in operation which is electrically driven. In addition facilities are provided to store large quantities of liquid oxygen to reduce oxygen losses. Further to BSC recommendations a unit has been set up to eliminate line leakages, rectification of which at present is providing a saving of around Rs 9.4 lakh per month to BSL according to the statistics provided.

However analysis of annual statistics show that over the past three years the oxygen losses have increased progressively from 15.78% to 22.4%, an increase in loss of 42% from 1987/88 figures. The energy usage for the production of oxygen is also higher by 33% over the same period (i.e. 2798 Gcal/m^3 in 1986/87 to 3738 Gcal/m^3 in 1989/90). The trend is disturbing and was not explained satisfactorily. It is recommended that the efficiency of oxygen production should be subject to a detailed audit as it appears that there may be significant savings available.

4.10.2 Lighting

In implementing BSC recommendations, the plant have carried out a detailed analysis of lighting load. This offers a potential saving of nearly 10 MW (Rs 360 lakh) of which 3 MW (Rs 106 lakh) have already been made largely through time control switching. Most of the unrealised saving will be due to more efficient lighting units.

4.11 Works Total

There has been a reduction of 2.8 Gcal/TCS in the 3 years with 89/90 being slightly worse than the previous year. This is a 21.4% reduction in actual specific energy.

The table 4.12 shows how the various departments contributed on a crude steel basis. Coke ovens, blast furnaces, sinter plant and miscellaneous and losses contributed 90% of the total saving.

Some of the saving is due to departmental changes in production ratio. Where the production decreases relative to crude steel there are savings and the reverse is of course true. Changes in production ratios account for 35% of the total saving. All departments up stream of the melting shops had lower production ratios, giving savings of 1.3 Gcal/TCS.

Those departments downsteam of steelmaking all had higher ratios and hence showed losses against the base year. The higher ratios could be for a number of reasons but it is most likely that the use of stock ingots and slabs has contributed. Unfortunately, due to the basis being crude steel, any improvement of yield would also show an adverse variance.

The savings due to pure departmental efficiency are also shown. All departments contributed with the minor (and technical) exception of the melting shop. The efficiency improvements contributed 65% of the total with the Coke ovens, Blast Furnace, Hot Strip Mill and Miscellaneous and Losses providing 70% of the sub total.

The energy usage for balanced production on the works definition has been reduced by 1.3 Gcal/TCS or 12.2%.

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BOKARO STEEL PLANT
ENERGY CONSUMPTION BY PROCESS (AND RELATED DATA)

TABLE 4.1 COKE OVENS	86/87	87/88	88/89	Apr 89 Feb 90 (89/90)	Difference 86/87 & 89/90 Gcal/T	%
Output kT/a Gross Coke	2843.5	3060.5	3045.4	(2809.0)	–	-1.2
Heat Input						
Coal Gcal/TP	8.704	8.702	8.664	8.346	-0.358	-4.1
Underfiring Gcal/TP	0.784	0.775	0.765	0.755	-0.029	-3.7
Power Gcal/TP	0.072	0.075	0.075	0.079	+0.007	+9.7
Steam Gcal/TP	0.109	0.098	0.089	0.098	-0.010	-10.0
Total Input Gcal/TP	9.669	9.65	9.593	9.278	-0.391	-4.0
Heat Output						
Coke Gcal/TP	6.093	6.117	6.199	6.281	+0.188	+3.1
Gas Gcal/TP	1.539	1.551	1.534	1.469	-0.070	-4.5
By-products Gcal/TP	0.294	0.3	0.292	0.297	+0.003	+1.0
Total Output Gcal/TP	7.926	7.968	8.025	8.047	+0.122	+1.5
Net Energy Usage Gcal/TP	1.743	1.682	1.586	1.231	-0.512	-29.5
Energy Yield Loss Gcal/TP	0.778	0.74	0.639	0.299	-0.479	-61.6
Energy Yields Loss % of coal in	8.9	8.4	7.4	3.6		
Energy Net of yield loss Gcal/TP	0.956	0.948	0.929	0.924	-0.032	-3.3
Production Ratio (act)	1.383	1.266	1.099	1.068		
Energy/T Crude Steel Gcal	2.41	2.129	1.743	1.315	-1.095	-45.4
Yield Coke/Coal (dry)	0.77	0.771	0.779	0.806		
Screen loss at C Ovens % of G.C	12.8	13	15.98	16.5		
Screen loss at B.F % B F Coke	7.67	13.2	9.26	9.62		
Overall Screen Loss, % G.C	19.5	24.5	23.6	24.5		

TABLE 4.2
SINTER PLANT

Output kT/a	2975	3223	3286	(3297)		+10.8
Breeze Gcal/TP	0.519	0.489	0.44	0.441	-0.078	-15.0
Ignition Gcal/TP	0.127	0.111	0.105	0.11	-0.017	-13.4
Power Gcal/TP	0.24	0.243	0.21	0.221	-0.019	-7.9
Total Gcal/TP	0.886	0.843	0.755	0.772	-0.114	-12.9
Production Ratio	1.447	1.333	1.186	1.254		
Energy/TCS Gcal	1.282	1.124	0.835	0.968	-0.314	-24.5
Return Sinter, % of Total Mix	40.2	35.3	32.3			
Skip Screenings % (assumed)	10	10	10	10		

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BOKARO STEEL PLANT
ENERGY CONSUMPTION BY PROCESS (AND RELATED DATA)

TABLE 4.3 BLAST FURNACES				Apr 89 Feb 90	Difference 86/87 & 89/90	
	86/87	87/88	88/89	(89/90)	Gcal/T	%
Output kT/a	2813	3123	3221	(3193)		+13.5
Coke Gcal/TP	4.302	4.153	4.129	4.196	-0.106	-2.5
Stove Gas Gcal/TP	0.821	0.782	0.748	0.732	-0.089	-10.8
Blast Steam Gcal/TP	0.503	0.459	0.43	0.43	-0.073	-14.5
Process Steam Gcal/TP	0.104	0.093	0.072	0.067	-0.037	-35.6
Power Gcal/TP	0.072	0.072	0.078	0.09	+0.018	+25.0
Input Energy Gcal/TP	5.802	5.559	5.457	5.515	-0.287	-4.9
Blast Furnace Gas out Gcal/TP	1.97	1.901	1.846	1.88	-0.09	-4.6
Net Energy Usage Gcal/TP	3.832	3.658	3.611	3.635	-0.197	-5.1
Coke - Gas Gcal/TP	2.332	2.252	2.283	2.316	-0.016	-0.7
Production Ratio	1.368	1.292	1.162	1.214		
Energy/TCS Gcal(act)	5.242	4.726	4.196	4.413	-0.829	-15.8
Productivity t/m3/d(U.V)	0.87	0.88	0.996			
Coke Rate kg/t	706	679	666			
Raw Flux kg/t	43	31	25			
Blast Temperature Degree C	989	1000	942	934		

TABLE 4.4
STEELMAKING - LD

Ouput kT/a	2056	2418	2771	(2630)		+27.9
Fuels Gcal/TP	0.334	0.304	0.269	0.26	-0.074	-22.1
Power Gcal/TP	0.163	0.156	0.141	0.15	-0.013	-8.0
Steam Gcal/TP	0.091	0.085	0.069	0.085	-0.006	-6.7
Oxygen Gcal/TP	0.187	0.234	0.235	0.258	+0.071	+38.0
Total Input Gcal/TP	0.775	0.779	0.714	0.753	-0.022	-2.8
Recovered Steam Gcal/TP	0.221	0.183	0.128	0.165	-0.056	-25.3
Recovered Gas Gcal/TP			0.016	0.026	+0.026	
Net Energy Gcal/TP	0.554	0.596	0.57	0.562	+0.008	+1.4
Gcal/TCS	0.554	0.596	0.57	0.562	+0.008	+1.4
Energy in 02 - kcal/m3	2798	3553	3665	3738		+33.6
02 usage m3/TCS	66.8	65.8	64	69		
Hot Metal kg/TCS	955.4	936.4	951.1	1014.3		
Lime kg/TCS	121	118	98			

BOKARO STEEL PLANT
ENERGY CONSUMPTION BY PROCESS (AND RELATED DATA)

TABLE 4.5 ⁻⁻˙˙ARY ROLLING	86/87	87/88	88/89	Apr 89 Feb 90 (89/90)	Difference 86/87 & 89/90 GcaI/T	%
Output kT/a	1640	1976	2272	(2207)		+34.6
Fuel Gcal/TP	0.703	0.647	0.565	0.593	-0.110	-15.6
Power Gcal/TP	0.083	0.078	0.072	0.072	-0.011	-13.3
Steam Gcal/TP	0.029	0.022	0.004	0.003	-0.026	-89.7
Oxygen Gcal/TP	0.033	0.078	0.051	0.03	-0.003	-9.0
Total Gcal/TP	0.848	0.825	0.699	0.698	-0.150	-17.7
Production Ratio (act)	0.798	0.817	0.82	0.839		
Energy/TCS Gcal	0.677	0.674	0.573	0.586	-0.091	-13.4
Cold Charge %	29	25.3	21.1	22.2		
Track time hrs-min	'6-08	'6-15	'5-34	'5-52		

TABLE 4.6
HOT STRIP MILL

Output kT/a	1551	1878	2205	(2212)		+42.6
Fuel Gcal/TP	1.153	1.049	0.964	0.933	-0.220	-19.1
Power Gcal/TP	0.328	0.306	0.273	0.285	-0.043	-13.1
Steam Gcal/TP	0.045	0.032	0.015	0.017	-0.028	-62.2
Total Input Gcal/TP	1.526	1.387	1.252	1.235	-0.291	-19.1
Recovered Steam Gcal/TP	0.083	0.065	0.044	0.049	-0.034	-41.0
Net Energy Usage	1.443	1.322	1.208	1.186	-0.257	-17.8
Production Ratio	0.754	0.777	0.796	0.841		
Energy/TCS Gcal	1.088	1.027	0.962	0.997	-0.091	-8.4
Hot Steel Charged %	0	0	5.1	11.2		

TABLE 4.7
COLD ROLLINGS MILLS

Output kT/a	254	330	434	(488)		+92
Fuel Gcal/TP	0.49	0.438	0.464	0.339	-0.151	-30.8
Power Gcal/TP	0.58	0.555	0.459	0.516	-0.064	-11.0
Steam Gcal/TP	0.633	0.319	0.215	0.218	-0.415	-65.6
Total Gcal/TP	1.703	1.312	1.138	1.073	-0.63	-37.0
Production Ratio	0.124	0.136	0.157	0.186		
Energy/ton Crude Steel, Gcal	0.211	0.178	0.179	0.2	-0.011	-5.2
Re-annealing %			10.4	7.2		

BOKARO STEEL PLANT
ENERGY CONSUMPTION BY PROCESS (AND RELATED DATA)

TABLE 4.8 STEAM GENERATION				Apr 89 Feb 90	Difference 86/87 & 89/90	
	86/87	87/88	88/89	(89/90)	Gcal/T	%
Output kT/a	6946	7048	8051	(9227)		+32.8
Fuel Gcal/TP	0.766	0.768	0.749	0.745	-0.021	-2.7
Steam Gcal/TP	0.082	0.081	0.08	0.059	-0.023	-28.0
Power Gcal/TP	0.082	0.081	0.084	0.081	-0.001	-1.2
Total Gcal/TP	0.93	0.93	0.913	0.885	-0.045	-4.8
Output Steam Gcal/TP	0.83	0.83	0.838	0.83		
Net Usage Gcal/TP	0.1	0.1	0.085	0.055	-0.045	-45.0
Production Ratio	3.378	2.915	2.905	3.508		
Energy/TCS Gcal	0.338	0.292	0.247	0.193	-0.145	-42.9
Notional Efficiency %	89.2	89.2	90.7	93.8		
100 ata steam reduced to 39 ata, %		27.3	26.6	21.5		
Steam reduced to 8 ata %		15.2	14.4	9.3		
Total HP Steam/ton CS, tons	3.378	2.915	2.905	3.508	-	+3.8
Steam for power production (net) and BF blowing kT/a	4252	4348	5154	5964		
Process steam (by diff) kT/a	2694	2700	2897	2494		
Waste Heat Steam kT/a	882	853	686	752		
Total Process Steam kT/a	3576	3553	3583	3246		
Total Process Steam T/TCS	1.738	1.469	1.293	1.346		-22.6

BOKARO STEEL PLANT
ENERGY CONSUMPTION BY PROCESS (AND RELATED DATA)

TABLE 4.9 POWER GENERATION				Apr 89 Feb 90	Difference 86/87 & 89/90	
	86/87	87/88	88/89	(89/90)	Gcal/T	%
Output Gwh/a	611.4	629.1	791.7	(1155)	-	+88.9
Steam input Gcal/Gwh	5.478	5.54	5.443	4.617	−0.861	−15.7
Power output Gcal/Gwh	3	3	3	3	−	-
Steam/Pass out Gcal/Gwh	1.901	1.957	1.702	1.062	−0.839	−46.6
Net Energy Gcal/Gwh	0.577	0.583	0.741	0.555	−0.022	−3.8
Production Ratio Gcal/TCS	0.297	0.26	0.286	0.439		
Energy/TCS, Gcal	0.171	0.152	0.212	0.244	+0.073	+42.5
Notional Efficiency	50.4	50.8	47.1	41.6		
Purchased power to works Gwh/a	745.8	836.1	701.1			
Total used on works Gwh/a	1357.2	1457.2	1492.8			
Kwh/TCS	660	603	538.7			

TABLE 4.10
AUXILLIARIES AND LOSSES

Fuels Gcal/TCS	0.217	0.183	0.141	0.137	−0.080	−36.9
Power Gcal/TCS	0.517	0.462	0.384	0.423	−0.094	−18.2
Steam Gcal/TCS	0.166	0.135	0.087	0.123	0.043	−25.9
Oxygen Gcal/TCS	0.155	0.114	0.121	0.16	+0.005	+3.2
Total Gcal/TCS	1.055	0.894	0.733	0.843	−0.211	−20.0
BF Gas loss %		4.52	3.67	3.5		
CO Gas loss %		0.85	0.63	0.58		
Oxygen loss %		15.8	19.2	22.4		
Electricity %		2.1	1	1.7		
8 ata Steam %		4.5	7.1	8.7		

TABLE 4.11
WORKS TOTAL

Crude Steel Output kT/a	2056	2418	2771	(2630)		
Energy/TCS(Actual) Gcal	13.115	11.788	10.29	10.31	−2.805	−21.4
Energy/TCS(Balanced) Gcal	10.606	9.933	9.396	9.315	−1.291	−12.2

TABLE 4.12

BOKARO STEEL PLANT ANALYSIS OF DEPARTMENTAL CHANGES			
COMPARISON OF 86/87 AND 89/90	CHANGES/TON CRUDE STEEL		
DEPARTMENT	DUE TO EFFICIENCY GcaI/TCS	DUE TO PROD.RATIO GcaI/TCS	TOTAL GcaI/TCS
Coke Ovens	0.547	0.548	1.095
Sinter Plant	0.143	0.171	0.314
Blast Furnaces	0.239	0.590	0.829
Steel Plant	(0.008)*	0	(0.008)
Primary Mill	0.125	(0.034)	0.091
Hot Strip Mill	0.217	(0.126)	0.091
Cold Rolling Mill	0.117	(0.106)	0.011
Steam Generation	0.158	(0.013)	0.145
Power Generation	0.009	(0.082)	(0.073)
Miscellaneous and Losses	0.211	0	0.211
TOTAL	1.758	0.948	2.706

* FIGS. IN BRACKETS ARE ADVERSE CHANGES